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SILVER COINAGE HISTORICALLY CONSIDERED.

By Henry Dunning MacLeod.

IN the September *Nineteenth Century* Mr. J. P. Heseltine makes an appeal to monometalists to give a statement of the reasons for the faith which is in them. I propose in the following remarks to give a very brief and concise account of the facts and arguments on which our present system of monometalism is founded.

Charlemagne established the system of coinage which was adopted throughout western Europe. He made the pound weight of silver the standard, and divided it into 240 pieces called pennies. For a considerable period the kings of France coined these pennies at their full weight and fineness. But about the beginning of the twelfth century they began not only to diminish their weight, but to debase their purity. They considered it part of their inalienable divine right to declare that their subjects should accept the diminished and debased coins at the same value as the good coins of full weight. They further complicated matters by issuing gold coins, and they considered it as part of their divine right to change the rating of these coins with respect to each other as often as they pleased.

These constant tamperings with the coinage produced commotions and disturbances, and drove away foreign trade from the country. At length that great sovereign, Charles the Fifth, justly surnamed the Wise, perceived that the only way to restore prosperity to the country was to reform the coinage. He referred the matter to one of his wisest and most trusted councillors, Nicolas Oresme, who, in answer to the appeal of his sovereign, drew up his now famous *Traictie de la première invention des Monnoies*, in twenty-six chapters.

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After explaining the true nature and uses of money, he laid down the following principles:

1. That the sovereign has no right to diminish the weight, debase the purity, or change the denomination of the coinage. To do so is robbery.

2. That the sovereign can in no case fix the value or the purchasing power of the coins. If he could do so, he could fix the value of all other commodities; which was indeed the idea of mediæval sovereigns.

3. That the legal ratio of the coins must strictly conform to the relative market value of the metals.

4. That if the fixed legal ratio of the coins differs from the natural or market value of the metals, the coin which is underrated entirely disappears from circulation, and the coin which is overrated alone remains current.

5. That if degraded and debased coin is allowed to circulate along with good and full-weighted coin, all the good coin disappears from circulation, and the base coin alone remains current, to the ruin of commerce.

This great treatise, which may be said to stand at the head of modern economical literature, contains the fundamental principles of money which are now accepted by all sound economists; and it was out of these principles that the system of monometalism was developed at the close of the seventeenth century.

The same ideas and evils existed all through Europe, and were called *morbus numericus*.

Poland, which then comprehended the modern Prussia, was afflicted with these evils. Sigismund the First, King of Poland, sought the advice of Copernicus, who was a member of the Prussian Diet. At the instance of Sigismund, Copernicus drew up a masterly treatise on money, which he entitled *Ratio monetæ cudendæ*, which has only been discovered within the present century, and is included in the magnificent edition of his works printed at Warsaw in 1854.

Copernicus had no knowledge of the treatise of Oresme, written 160 years before his time, but he came to exactly the same conclusions. They were:

1. That it is impossible for the prince to regulate the value of the coins, or of any other commodity.

2. That all the prince or the law can do is to maintain the coins at their full legal weight, purity, and denomination.

3. That it is robbery for the prince to change the denomination, diminish the weight, or debase the purity of his coins.

4. That it is impossible for good full-weighted coin and base and

degraded coin to circulate together; that all the good coin is hoarded, melted down, or exported, and the degraded and debased coin alone remains in circulation.

5. That the coins of gold and silver must bear the same ratio to each other as the metals do in the market. Oresme and Copernicus quite agreed that it is impossible to keep gold and silver coins in circulation together in unlimited quantities at a fixed legal ratio differing from the market value of the metals.

6. That when good coins are issued from the mint, all the base and degraded coins must be withdrawn from circulation; or else all the good coins will disappear, to the ruin of commerce.

The early English sovereigns did not debase their coinage, but immense quantities of base and degraded coins were in circulation, and consequently all the good coin disappeared as soon as it was issued from the mint. Edward the First was the first to diminish the weight of the coin. He coined 243 pennies out of the pound weight of silver, and by successive diminutions the pound weight of silver was coined into 744 pennies under Elizabeth. The instant disappearance of the good coin as soon as it was issued from the mint was the subject of repeated debates in Parliament for some centuries, and was an inscrutable puzzle to financiers and statesmen.

At last Sir Thomas Gresham explained to Queen Elizabeth that good and bad coin cannot circulate together, but that the good coin disappears, and the bad coin alone remains current. As Sir Thomas Gresham was the first in this country to explain that permitting bad coin to circulate was the cause of the disappearance of the good coin, I suggested in 1858 that this should be called Gresham's law, which name has now been universally accepted. But as Oresme and Copernicus had both declared this law before him, it ought to be called the law of Oresme, Copernicus, and Gresham.

This great fundamental law of the coinage soon became common knowledge. It is thus stated in a pamphlet in 1696:

"'When two sorts of coin are current in the same nation of like value by denomination but not intrinsically [*i. e.*, in market value], that which has the least value will be current, and the other as much as possible will be hoarded,' or melted down, or exported, we may add."

This great fundamental law of the coinage has been found to be universally true. Henceforth it was recognized and acknowleged in all subsequent discussions on the coinage. It applies in the following cases:

1. If the coins consist of one metal only, and clipped, degraded, and debased coins are allowed to circulate together with good coins, all the good coins disappear: they are either hoarded, or melted down, or exported, and the bad coin alone remains in circulation.

2. If coins of two metals, such as gold and silver, are allowed to circulate together in unlimited quantities at a fixed legal ratio which differs from the market ratio of the metals, the coin which is underrated disappears from circulation, and the coin which is overrated alone remains current.

3. As a necessary corollary, it follows that it is impossible to maintain a fixed par of exchange between countries which use different metals as their standard unit.

This law is not confined to single and separate States; it is not limited in time or space; it is absolutely universal: and it is equally impossible for the whole world to maintain coins of two or more metals in circulation together in unlimited quantities at a fixed legal ratio which differs from the natural, or market, value of the metals, as it is for single and separate States to do so.

The explanation of this problem, which was an inscrutable mystery to statesmen and financiers for so many ages, is extremely simple. If shillings are allowed to circulate together, some of which are worth twelvepence and others only ninepence, and every one is allowed to pay his debts in which of them he pleases, he will naturally pay his debts with the shillings worth ninepence and keep the shillings worth twelvepence in his pocket. Or, if shillings worth twelvepence have no more value than shillings worth ninepence, bullion-dealers collect all the heavy coins they can and melt them down into bullion, in which form they have more value, or they export them to foreign countries where they have their full value. Thus the underrated coins have invariably been found to disappear in one or other of these three ways.

It is exactly the same in all cases in which persons are allowed to pay their debts in things which have nominally the same value, but in reality are of different values. When persons are allowed to pay their rents in kind, they naturally select the worst portions of the produce to pay their landlords, and keep the best portions for themselves.

If merchants received an order for so many yards of cloth, and the law allowed two different yard measures to be used,—one of three feet and one of two feet,—merchants would naturally fulfil their orders in yards of two feet rather than in yards of three feet. It is only natural that persons should pay their debts in the cheapest form to themselves.

So, if the law allows debtors to pay their debts in coins of different metals which are rated equally in law, but whose values differ in the market of the world, they will naturally pay their debts in the coin which is overrated, and keep the coin which is underrated at home. Then inevitably the coin which is underrated disappears from circulation, and the coin which is rated above its natural or market value alone remains current; and this is true whether single and separate

States do so, or whether the whole world does so. If, then, the whole world were to agree to rate a coin below its market value, it would inevitably disappear from circulation; for the whole world can no more by universal agreement make nine equal to twelve than any separate States can.

The bimetalists contend that, if a fixed ratio between the metals were established by international agreement, the market value of the metals would conform to it; that by so doing the metals would circulate together in unlimited quantities at the fixed ratio, and so augment the currency or circulating medium of the world; that every one would bring his gold and silver to be coined; that these might be used indifferently in the payment of debts, and that a stable ratio of exchange might be established between all nations.

Most unfortunately, the experience of bimetalism in every country for five hundred years entirely negatives all these allegations.

1. It is proved that the fixed legal ratio between the coins never had the slightest effect on the relative market value of the metals.

2. That when the fixed legal ratio between the coins differed from the relative market value of the metals, the coins of that metal which was underrated invariably disappeared from circulation, and the coins of the metal which was overrated alone remained current: and that, as the market value of the metals changed, gold and silver alternately drove each other out of circulation, so that there was no augmentation of the currency, but one metal simply displaced the other.

3. That when one metal is at a premium,—*i. e.*, its market value exceeds the legal ratio,—no private persons bring that metal to be coined, because it would be simply to diminish the value of that metal. The master of the mint stated in 1816 that during the whole of the reign of George the Third no more than £64,500 of silver was coined, because during all that period silver had been at a premium.

The bimetalists are energetically urging governments to adopt their doctrines. Well, we have two examples of the ideal condition of the bimetalists, and we shall see with what results.

In 1666 it was enacted that all persons might bring their gold and silver to the mint to be coined free of all charge. By the mint indentures the gold guinea was coined to be of the value of 20s. in silver, but no legal ratio was fixed between the coins: the public were to receive them at such a rating as they pleased. Guineas, instead of being current at 20s. according to the mint indentures, passed current at 22s. The silver coins became constantly more degraded, until at last they were clipped down to half their weight. After the great recoinage by William the Third, guineas were successively reduced by proclamation, and a treasury warrant fixed that they should be received

at the rate of 21s. 6d. at the treasury. But still all the good silver coin disappeared from circulation as soon as it was issued from the mint. In their perplexity the government referred the whole matter to Newton, who showed that the true value of the guinea was only 20s. 8d., according to the market value of the metals, and that in consequence of this all the good silver was at once exported. He recommended that the guinea should be reduced to 21s. by way of experiment. This was accordingly done; but the guinea was still overrated by 4d., and the consequence was that there was no good silver in circulation during the whole of the century. It then became an established custom among merchants that all obligations became payable in gold only, as the cheaper metal. The foreign exchanges were settled in gold; so ever since 1718 England has become a gold monometalic country, and in public estimation the standard was changed from silver to gold, although the obsolete and effete words of bimetalism lingered on in the statute-book for another hundred years. At the great recoinage of 1816, that which had become established by mercantile usage was enacted by law. Gold was adopted as the sole standard, and silver was coined only in limited amounts, and made legal tender for only 40s. Ever since then England has enjoyed the most perfect system of coinage ever devised by the ingenuity of man, and has been perfectly free from all coinage troubles.

I will now take the case which the bimetalists cite as the golden age of bimetalism. France endeavored to maintain bimetalism from 1113 to 1874. But during that time the mint price of the marc of gold has been changed 146 times, and the mint price of the marc of silver 251 times, and the changes of the rating between gold and silver were innumerable; at last, in 1726, the ratio of gold to silver was fixed at 1 to 14½. But silver was rated too highly, and by the same law that gold became the standard in England silver became the standard in France. In 1803 the ratio of gold to silver was fixed at 1 to 15½, at which it still nominally remains. Gold and silver coins were made equally legal tender at that ratio. But the French liberating armies plundered all the sanctuaries of the countries they came to liberate of their treasures. Vast quantities of silver were coined, and the market ratio of silver to gold became 17 to 1. Thus gold was at a premium from 1803 to 1850, and consequently there was no gold in general circulation during that period. I myself can testify that in 1839 there was scarcely a gold coin to be seen in common circulation in France. There was of course plenty of gold coin to be had at the Bank of France, but those who wanted it had to pay a premium for it.

Soon after 1850 the gold supplies came in from California and Australia, and the market ratio of silver to gold, which was 15¾ to 1,

rose to 15⅓ to 1; and that apparently slight change in the market ratio, while the legal ratio remained at 15½ to 1, was sufficient to displace from 150,000,000 to 200,000,000 of silver and to substitute an equal quantity of gold for it. I was residing at a French seaport town in 1857, and every steamer that came in was loaded with casks of Scotch whiskey going to be transmuted into French brandy, and every steamer that went out had its deck piled with bags of five-franc pieces. It was the same at every other port. Silver departed from France in a flood, and at length became so scarce that it became necessary to coin those detestable five-franc gold pieces. This case shows the immense practical importance of even a very slight difference between the legal ratio and the market ratio of gold and silver, and decisively negatives the allegation of the bimetalists that gold and silver can circulate together in unlimited quantities at a legal ratio differing from the market ratio.

In 1865 the Latin Union was formed, but even then Italy declared herself in favor of a single gold standard. In 1867 the value of silver began to fall and to create uneasiness. A commission was appointed, which by a majority declared against the adoption of a single gold standard. In 1868 the fall became more accentuated, and a commission by a majority declared in favor of a single gold standard. Another commission in 1869-70 reported still more strongly in its favor. In June, 1870, Prussia appointed a commission to consider the expediency of adopting a single gold standard, but the war of 1870 put an end to all these discussions. By acts of 1871 and 1873 Germany adopted a single gold standard. In December, 1872, Belgium adopted a single gold standard. The matter then became still more pressing, and a great debate was held at the Société d'Economie Politique, in which the government was represented by M. de Parieu. The majority strongly decided on the necessity of adopting a single gold standard. In accordance with this resolution, France closed her mints to the free coinage of silver in 1874, and became a gold monometalic country. The bimetalists persistently assert that it was the closing of the French mints in 1874 that caused the fall in the value of silver, whereas it was exactly the contrary. It was the fall in the value of silver which compelled the closing of the mints to the free coinage of silver, and its necessity was foreseen six years before it took place, and it was only done after the fullest discussion and in accordance with the advice of the highest authorities.

I have now to lay before your readers an instance which is perfectly novel to the general public. As the East India company extended its dominion it was greatly plagued and tormented by the multiplicity of gold and silver coins—994 in number—which were in circulation in

India of different weights and fineness. In 1766 they endeavored to establish bimetalism, but it entirely failed. In their perplexity they sought the advice of Sir James Steuart, who was the ablest economist in England before the publication of the "Wealth of Nations" in 1776. In 1772 he drew up a treatise on money for them, showing, in exact accordance with all the preceding authorities since Oresme, that it is impossible that gold and silver can circulate together in unlimited quantities at a fixed legal ratio differing from the market value of the metals. In 1805 Lord Liverpool's great master treatise on the subject was published, and as soon as it reached India, in 1806, the governor-general in council took it into consideration, and issued a minute to the subordinate governments condemning bimetalism in the strongest terms, and declaring its entire adhesion to the doctrines of Lord Liverpool. By the courtesy of the India office I am enabled to make this minute public for the first time. It said:

"A proportion between the gold and silver coins is fixed by law according to the value of the metals, and it may be on the justest principles, but, owing to a change of circumstances, gold may become of a greater value in relation to silver than at the time the proportion was fixed; it therefore becomes profitable to exchange silver for gold; so the coin of that metal is withdrawn from circulation; and if silver should increase in its value in relation to gold, the same circumstances would tend to reduce the quantity of silver coin in circulation. As it is impossible to prevent the fluctuations in the value of the metals, so it is equally impracticable to prevent the consequences thereof in the coins from those metals. . . .

"But there is a radical defect in the principle itself of giving a fixed value to metals in coin that in their nature are subject to continual change."

The minute then declared the unhesitating adhesion of the council to the principle that one metal only should be adopted as the standard unit, though coins of other metals might circulate at their market value. The minute decided that silver should be the sole standard, which was perhaps natural under the circumstances. But the error was most unfortunate, and, having been carried out by Lord Dalhousie with the extremest severity by the total demonetization of gold, has been the cause of all our present troubles.

The principles first declared by Petty, Locke, and Harris, and fully developed by Lord Liverpool, which received the adhesion of the Indian government in 1806, that one metal only should be adopted as the standard, and that subsidiary coins of other metals might be issued in limited quantities and made legal tender only for small amounts, were adopted by the British government in 1816.

Bimetalists now admit that no single country can maintain bimetalism by itself; but they allege that, if all nations of the world, or at least the principal of them, were to agree to fix a common ratio, that would maintain a fixed value between them and bring about a stable exchange between all nations. But such ideas are a dēlusion. When great laws of nature are once proved, they operate throughout the whole world, and not on single countries only. An international agreement can no more make nine equal to twelve than any single country can. If an international agreement were made that the ratio between gold and silver should be 1 to 15½, when the market ratio was 1 to 35, the simple result would be that all debtors would discharge their debts at 10s. in the pound, gold would entirely disappear from circulation, and silver would be the sole metalic currency of the world.

In 1830 Mr. Attwood brought forward a motion to reëstablish bimetalism. Silver had then fallen only 5 per cent., so that Mr. Attwood's plan would have declared 19s. in silver equal to 20s. in gold. But Mr. Herries, master of the mint, Mr. Huskisson, and Sir Robert Peel unanimously declared that such a thing would bring on a national bankruptcy in twenty-four hours. Sir Robert Peel said: "The notion of a double standard was totally fallacious; . . . all would turn to confusion, and public ruin must be the consequence." The motion was negatived without a division.

The bimetalists tell us that bimetalism would lead to a golden age of boundless prosperity; Mr. Herries, Mr. Huskisson, and Sir Robert Peel tell us that it would land us in national bankruptcy in twenty-four hours. Which of these parties will sensible men believe?

The bimetalists tell us that a legal ratio between gold and silver was maintained both in England and France for centuries. What they say is true in the letter, but utterly false in the spirit. They would have us believe that this had the effect of keeping the market value of the metals at that rate, and that both metals remained in circulation together at the fixed ratio. It is true that bimetalism was printed in the statute-books of both countries for centuries, but it was invariably found that the metal which was overrated invariably drove out the metal which was underrated from circulation, and alone remained current. Under the law of bimetalism the two metals never circulated together in any country. So far from the fixed legal ratio governing the value of the metals, governments had, from time to time, to alter the legal ratio, so as to conform to the market ratio, and all civilized governments have now seen the necessity of abandoning this fallacy, and of conforming themselves to the demonstrated laws of nature.

Bimetalism is only part of a system which prevailed in every country for centuries. Statesmen thought that they could regulate the value of commodities by law, and the statute-book contained many such laws. But experience showed that such laws were absolutely inoperative, and, after having been abandoned in practice, were at length expunged from the statute-book. The attempt to restore bimetalism is simply the endeavor to revive this exploded economic fallacy.

If it were possible to establish a fixed ratio between gold and silver by international agreement, it would be equally possible to fix the value of all commodities. Innumerable mercantile catastrophes are caused by the unexpected change in the value of commodities: why not then fix the value of all commodities, and so remove the cause of multitudes of mercantile calamities?

Agriculturists are suffering the extremest depression from the fall in the value of their produce. Why not then fix the value of corn at a remunerative price by international agreement? If it were printed in all the statute-books of the world that the price of wheat should be 60s. a quarter, does any person of common sense suppose that the price of wheat would rise one farthing?

It was formerly found impossible to fix the value of the metals, or the value of inconvertible paper money, by laws sanctioned by the direst penalties: how then can it be possible to do so by merely printing so many words in a book?

Mr. Heseltine complains of the paucity of writers in favor of monometalism. But there is no need of a multitude of writers on the subject. The indubitable historical facts which prove the impossibility of bimetalism are contained in the histories of the coinage of every country of Europe for five centuries. And the monumental works of Oresme, Copernicus, Gresham, Petty, Locke, Newton, Harris, Lord Liverpool, the minute of the government of India in 1805, and the decision of the British government in 1816, contain, among many others, the arguments against bimetalism and in favor of monometalism which are unanswered and unanswerable. There is nothing to be added to what they have already said, and their arguments can gain no additional strength by being repeated by scores of writers. Neither do fallacious assertions become true by being repeated a multitude of times.

Moreover, every government in Europe, after having vainly attempted to maintain bimetalism for five centuries, has abandoned it as impracticable and injurious, and adopted monometalism. This course of statesmen, who are responsible for the administration of great States, is of infinitely more worth than any number of writers.—*Nineteenth Century*

MODERN THEORIES AS TO ELECTRICITY.

By Henry A. Rowland.

IT is not uncommon for electricians to be asked whether modern science has yet determined the nature of electricity, and we often find difficulty in answering the question. When the latter comes from a person of small knowledge which we know to be of a vague and general nature, we naturally answer it in an equally vague and general manner: but when it comes from a student of science anxious and able to bear the truth, we can now answer with certainty that electricity no longer exists. Electrical phenomena, electrostatic actions, electromagnetic actions, electrical waves,—these still exist and require explanation; but electricity, which, according to the old theory, is a viscous fluid throwing out little amoeba-like arms that stick to neighboring light substances and, contracting, draw them to the electrified body, electricity as a self-repellant fluid or as two kinds of fluid, positive and negative, attracting each other and repelling themselves,—this electricity no longer exists. For the name electricity, as used up to the present time, signifies at once that a substance is meant, and there is nothing more certain to-day than that electricity is not a fluid.

This makes the task of one who attempts to explain modern electrical theory a very difficult one, for the idea of electricity as a fluid pervades the whole language of electrical science, and even the definitions of electrical units as adopted by all scientists suggest a fluid theory. No wonder, then, that some practical men have given up in despair and finally concluded that the easiest way to understand a telegraph line is to consider that the earth is a vast reservoir of electrical fluid, which is pumped up to the line wire by the battery and finally descends to its proper level at the distant end. Is not this the proper conclusion to draw from that unfortunate term "electric current"? Remembering this fact,—that we cannot yet free ourselves from these old theories, and exactly suit our words to our meaning,—we shall now try to understand the modern progress in electrical theory.

This whole progress is based upon something in the human mind which warns us against the possibility of attraction at a distance through vacant space: Newton felt this impossibility in the case of gravitation, but it is to Faraday that we must look principally for the idea that electrical and magnetic actions must be carried on by means of a medium filling all space and usually called the ether. The development of this idea leads to the modern theory of electrical phenomena.

Take an ordinary steel magnet and, like Faraday, cover it with a

sheet of paper, and upon this sprinkle iron filings. Mapped before us we see Faraday's lines of magnetic force extending from pole to pole. We can calculate the form of these lines on the supposition that a magnetic fluid is either distributed over the poles of the magnet or on its molecules, assuming that attraction takes place through space without an intervening medium. But at this idea the mind of Faraday revolted, and he conceived that these lines, drawn for us by the iron filings, actually exist in the ether surrounding the magnet; he even conceived of them as having a tension along their length and a repulsion for one another perpendicular to their length.

Two magnets, then, near each other, become connected by these lines, which, like little elastic bands always pulling along their length, strive to bring the magnets together. These so-called lines of force (now called tubes of force) were, by his theory, conducted better by iron and worse by bismuth than by the ether of space, and so gave the explanation of magnetic attraction and diamagnetic repulsion.

The same theory of lines of force was also applied by Faraday to electrified bodies, and thus all electrostatic attractions were explained. By this idea of lines of force it will be seen that Faraday did away with all action at a distance and with all magnetic and electrical fluids, and substituted, instead, a system in which the ether surrounding the magnet or the electrified body became the all-important factor and the magnet or electrified body became simply the place where the lines of force ended: where a line of magnetic force ended, there was a portion of *imaginary* magnetic fluid; where a line of electric force ended, there was a portion of *imaginary* electric fluid. As the quantities of so-called plus and minus electricity in any system are equal, we can thus imagine every charged electrical system to be composed of a group of tubes of electrical force (more strictly electric induction) which unite the plus and minus electrified bodies, each unit tube having one unit of plus electricity on one end and one unit of minus electricity on the other. The tension along the tube explains the reason why such an arrangement acts as if there were real plus and minus electrical fluids on the ends of the tube, attracting one another at a distance. Consider a plus electrified sphere far away from other bodies. The lines of force radiate from it in all directions, and, being symmetrical around the sphere, they pull it equally in all directions. Now bring near it a minus electrified body, and the lines of force turn toward it and become concentrated on the side of the sphere toward such a body. Hence the lines pull more strongly in the direction of the negative body, and the sphere tends to approach it.

In the case of a conducting body the lines of force always pass outwards perpendicularly to the surface, and hence, if we know the distri-

bution of the lines over the surface, or the so-called surface density of the electricity, we can always tell in which direction the body tends to move. It is not necessary to know whether there are any attracting bodies near the conductor, but only the distribution of the lines. These lines then do away with all necessity for considering action at a distance, for we only have to imagine a kind of ether in which lines of force with given properties can exist, and we have the explanation of electric attraction.

But the question now arises as to how the lines of electric force can be produced in the ether, or, in other words, how bodies can be charged.

In the first place we know that equal quantities of plus and minus electricity are always produced. As an illustration, suppose it is required to charge two balls with electricity. Pass a conducting wire between them with a galvanic battery in its circuit. The galvanic battery generates the lines of force; these crowd together around it and push each other sideways until their ends are pushed down the wire and many of them are pushed out upon the balls.

When the tension backwards along the lines of force just balances the forward push of the electromotive force of the battery, equilibrium is established. If the wire is a good conductor, there may be electrical oscillations before the lines come to rest in a given position, and this I shall consider below.

The motion of the ends of the lines of force over and in the wire constitutes what is called an electric current in the wire which is accompanied by magnetic action around it and also by waves of electromagnetic disturbance which pass outward into space.

If, after equilibrium is established, we remove the wire, we have simply two charged spheres connected by lines of electrostatic force and thereby attracted to each other. If we replace the battery by a dynamo or by an electric machine the effect is the same.

But there is another way by which bodies are often charged and that is by *friction*. In this case we can suppose the glass to take hold of one end of the lines of force and the rubber the other end and it is then only necessary to pull the bodies asunder to fill the space with lines. The friction is merely needed to bring the two bodies into intimate contact and remove them gently from each other.

The following considerations may guide us in understanding the details of the process. It is well known from Faraday's researches that a given quantity of electricity has a fixed relation to the chemical equivalents of substances. Thus it requires 10,000 absolute electromagnetic units of electricity to deposit 114 grams of silver, 68 grams of copper, 34 grams of zinc, etc.

Hence we can consider, for instance, in chloride of silver that the atoms of silver are joined to the atoms of chlorine by lines of electrostatic force which hold them to each other. If, by rubbing the chloride of silver, we could remove the chlorine on the rubber while leaving the silver, we could stretch them asunder and so fill space with the lines of electrostatic force. According to this theory, then, each atom has a number of lines of force attached to it, and it is only by stretching the atoms apart that we can fill an appreciable space with them and so cause electrostatic action at a distance.

We come to the conclusion, then, that all electrification is originally produced by separating the atoms of bodies from one another, which can be done by breaking contact, by friction, or by direct chemical action of one substance on another, or in some other manner not so common. The lines of electrostatic force in a case of electricity at rest must always begin and end on matter, and they can never have their ends in space free from matter. The ends can be carried along with the matter, constituting electric convection, or they can slide through a metallic conductor or an electrolyte or rarefied gas, making what we call an electric current; but, as they cannot end in a vacuum, they cannot pass through it. Thus we conclude that a vacuum is a perfect non-conductor of electricity.

The exact process by which the ends of the lines of force pass through and along a conductor can at present be only dimly imagined, and no existing theory can be considered as entirely satisfactory. In the case of an electrolyte, however, we can form a fairly perfect picture of what takes place as the decomposition goes on. Thus, in the case of zinc and copper in hydrochloric acid, we can imagine the zinc plate attracting the chlorine of the acid, thus stretching out the natural line of electric force connecting the chlorine atom and the first hydrogen atom: we can imagine the atoms of chlorine and hydrogen in the body of the liquid recombining with each other and their lines of force uniting until they form a complete line long enough to stretch from the zinc to the copper plate: and all without once making a line of force without its end upon matter. We can further imagine the ends of this line sliding along the copper and zinc plates to the conducting wires and down their length, thus making an electric current and carrying the energy of chemical action to a great distance.

If the ends of the lines should slide along the wire without any resistance, the wire would be a perfect conductor: but all substances present some resistance, and in this case heat is generated. This we always find where an electric current passes along a wire: as to the exact nature of this resistance or the nature of metallic conduction in general we know little, but I believe we are approaching the time

when we can at least imagine what happens in this most interesting case.

Besides the heating due to the electric current, steadily flowing, we must now account for the magnetic lines of force surrounding the current and the magnetic induction of one current on the other.

If the current is produced by the ends of the tubes of electrostatic force moving along the wire, then we may imagine that the movement of the lines of electrostatic force in space produces the lines of magnetic force in a direction at right angles to the motion and to the direction of the lines of electrostatic force. At the same time we must be careful not to assume too readily that one is the cause and the other the effect: for we well know that a moving line of magnetic force (more properly induction) produces, as Faraday and Maxwell have shown, an electric force perpendicular to the magnetic line and to the direction of motion. Neither line can move without being accompanied by the other, and we can, for the moment, imagine either one as the cause of the other. However, for steady currents, it is simpler to take the moving lines of electrostatic force as the cause and the magnetic lines as the effect.

We have now to consider what happens when we have to deal with variable currents rather than steady ones.

In this case we know from the calculations of the great Maxwell and the demonstrations of Hertz that waves of electromagnetic disturbance are given out. To produce these waves, however, very violent disturbances are necessary. A fan waved gently in the air scarcely produces the mildest sort of waves, while a bee, with comparatively small wings moved quickly and vigorously, emits a loud sound.

So, with electricity, we must have a very violent electrical vibration before waves carrying much energy are given out.

Such a vibration we find when a spark passes from one conductor to another. The electrical system may be small in size, but the immensely rapid vibrations of millions of times per second, like the quick vibration of a bee's wing, sends out a volume of waves that a slowly moving current is not capable of producing. The velocity of these waves is now known to be very nearly 300,000 kilometers per second. This is exactly the velocity of waves of light, or other radiation in general, and there is no doubt at present in the minds of physicists that these waves of radiation are electromagnetic waves.

By this great discovery, which almost equals in importance that of gravitation, Maxwell has connected the theories of electricity and of light, and no theory of one can be complete without the other. Indeed they must both rest upon the properties of the same medium which fills all space—the ether.

Not only must this ether account for all ordinary electrical and magnetic actions, and for light and other radiation, but it must also account for the earth's magnetism and for gravitation.

To account for the earth's magnetism, we must suppose the ether to have such properties that the rotation of ordinary matter in it produces magnetism. To account for gravitation it must have such properties that two masses of matter in it tend to move toward each other with the known law of force, and without any loss of time in the action of the force. We know that moving electrical or magnetic bodies require a time represented by the velocity of light before they can attract each other in the line joining them. But, for gravitation, no time is allowable for the propagation of the attraction.

But the problem is not so hopeless as it at first appears. Have we not in two hundred and fifty years ascended from the idea of a viscous fluid surrounding the electrified body and protruding arms outward to draw in the light surrounding bodies to the grand idea of a universal medium which shall account for electricity, magnetism, light, and gravitation?

The theory of electricity and magnetism reduces itself, then, to the theory of the ether and its connection with ordinary matter, which we imagine to be always immersed in it. The ether is the medium by which alone one portion of matter can act upon another portion at a distance through apparently vacant space.

Let us then attempt to see in greater detail what the ether must explain in order that we may, if possible, imagine its nature.

1st. It must be able to explain electrostatic attraction. These electrostatic forces are mostly rather feeble as we ordinarily see them. Air breaks down and a spark passes when the tension on the ether amounts to about $\frac{1}{100}$ pound to the square inch. It is the air, however, that causes the break-down. Take the air entirely away, and we then know no limit to this force. In a suitable liquid it may amount to 500 times that in air or 5 pounds to 1 square inch, and become a very strong force indeed. In a perfect vacuum the limit is unknown, but it cannot be less than in a liquid, and may thus possibly amount to hundreds, if not thousands, of pounds to the square inch.

2d. It must explain magnetic action. These actions are apparently stronger than electrostatic actions, but in reality they are not necessarily so. A tension on the ether of only a few hundred pounds on the square inch will account for all magnetic attraction that we know of, although we are able to fix no limit to the force the ether will sustain. No signs have ever been discovered of the ether breaking down.

Again, we must be able to account for the magnetic rotation of polarized light as it passes through the magnetic field; and it can

only be accounted for by assuming a rotation around the lines of magnetic force. This action, however, takes place only while the lines of magnetic force pass through matter, and it has never been observed in the ether itself. The velocity of rotation, however, is immense, the plane of polarization rotating in some cases 300,000,000 times per second.

The ether must also account for the earth's magnetism. If we assume that magnetic lines of force are simply vortex filaments in the ether, we have only to suppose that the ether is carried around by the rotation of the earth, and we have the explanation needed. The magnetism of the earth would then be simply a whirlpool in the ether.

3d. The ether must be able to transmit to a distance an immense amount of energy either by means of electromagnetic waves as in light or by the similar action which takes place in the ether surrounding a wire carrying an electric current.

The amount of energy which can be transmitted by the ether in this manner is enormous, far exceeding that which can be carried by anything composed of ordinary matter. Thus take the case of sunlight: on the earth's surface illuminated by strong sunlight a horse-power of energy falls on every 7 square feet. At the surface of the sun the etherial waves carry energy outward at the rate of nearly 8000 horse-power per square foot!

Again, an electric wire as large as a knitting needle, surrounded with a tube half an inch in diameter in which a perfect vacuum has been made to prevent the escape of electricity, may convey to a distance a thousand horse-power, indeed even ten thousand or more horse-power, there being apparently no limit to the amount the ether can carry.

Compare this with the steam-engine, where only a few hundred horse-power require an enormous and clumsy steam pipe. Or, again, the amount carried by a steel shaft, which, at ordinary rate of speed, would require to be about a foot in diameter to transmit 10,000 horse-power.

When we compare the energy transmitted through a square foot of ether in waves, as in the case of the sun, with the amount that can be conveyed by means of sound waves in air or even sound waves in steel, the comparison becomes simply ridiculous, the ether being so immensely superior. As quick as light, the ether sends its wave energy to the distance of a million miles while the sluggard air carries it one. Thus, with equal strain on each, the ether carries away a million times the energy that the air could do.

4th. The ether must account for gravitation. For this purpose we are allowed no time whatever to transmit the attraction. As soon as the

position of two bodies is altered, just so soon must the line of action from one to the other be in the straight line between them.

If this were not so, the motion of the planets around the sun would be greatly altered. Toward the invention of such an ether, capable of carrying on all these actions at once, the minds of many scientific men are bent. Now and then we are able to give the ether such properties as to explain one or two of the phenomena, but we always come into conflict with other phenomena that equally demand explanation.

There is one trouble about the ether which is rather difficult to explain, and that is the fact that it does not seem to concentrate itself about the heavenly bodies. As far as we are able to test the point, light passes in a straight line through space even when near one of the larger planets, unless the latter possesses an atmosphere. This could hardly happen unless the ether was entirely incompressible or else possessed no weight.

If the ether is the *cause* of gravitation, however, it is placed outside the category of ordinary matter, and it may thus have no weight although still having inertia,—a thing impossible for ordinary matter where the weight is always exactly proportional to inertia.

Ether, then, is not matter, but something on which many of the properties of matter depend.

It is curious to note that Newton conceived of a theory of gravitation based on the ether, which he supposed to be more rare around ordinary matter than in free space. But the above considerations would cause the rejection of such a theory. We have absolutely no adequate theory of gravitation as produced by the ether.

To explain magnetism, physicists usually look to some rotation in the ether. The magnetic rotation of the plane of polarization of light together with the fact of the mere rotation of ordinary matter, as exemplified by the earth's magnetism, both point to rotation in the ether as the cause of magnetism. A smoke ring gives, to some extent, the modern idea of a magnetic line of force. It is a vortex filament in the ether.

Electrostatic action is more difficult to explain, and we have hardly got further than the vague idea that it is due to some sort of elastic yielding in the ether.

Light and radiation in general are explained when we understand clearly magnetic and electrostatic actions as the two are linked together with certainty by Maxwell's theory.

Where is the genius who will give us an ether that will reconcile all these phenomena with one another and show that they all come from the properties of one simple fluid filling all space, the life-blood of the universe—the ether?

THE DRAINAGE SYSTEM OF THE VALLEY OF MEXICO.

By Señor Don Matias Romero,

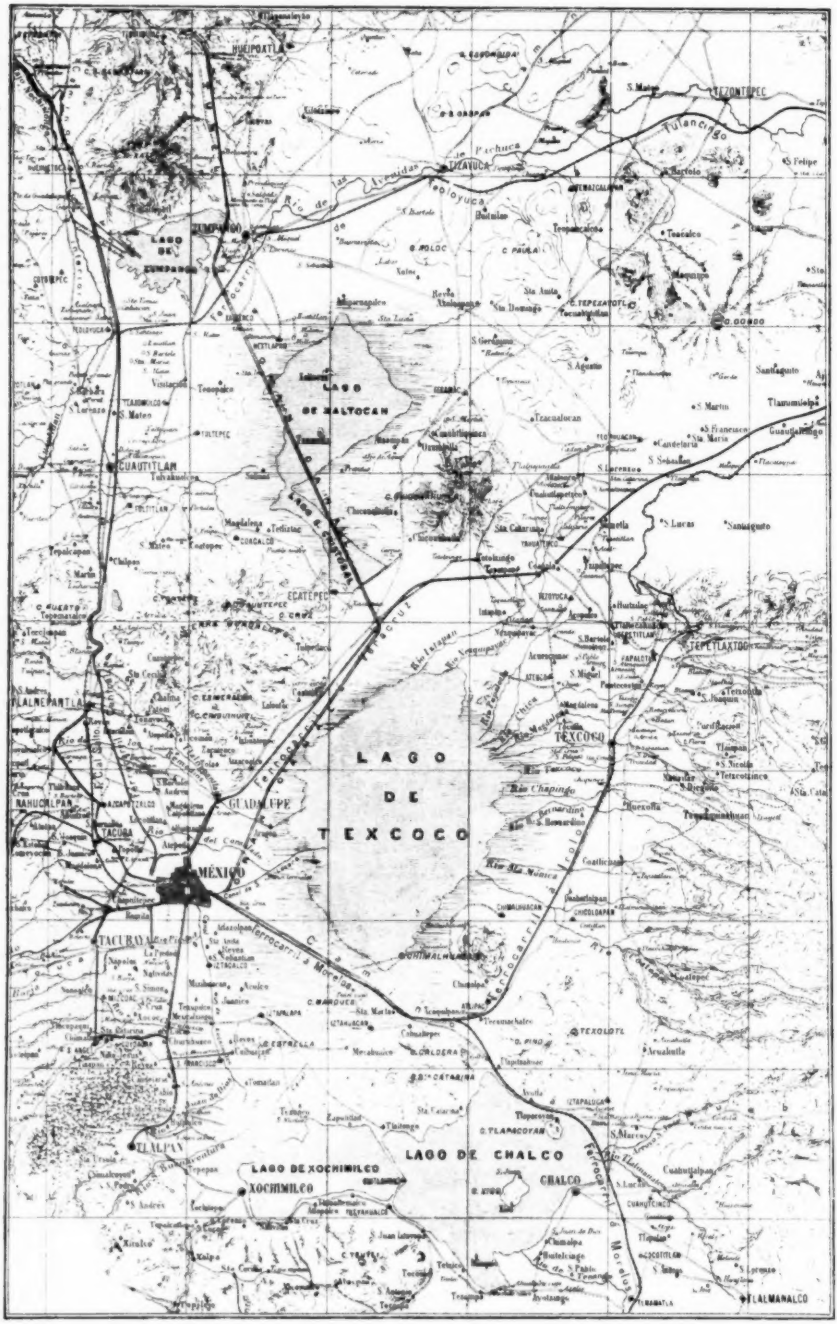
The Mexican Minister at Washington.

MEXICO is about finishing a great work, the drainage of the Mexican valley, which has required for its completion nearly three hundred years and many millions of dollars, and has cost the lives of hundreds of thousands of men. The necessity, importance, and magnitude of this work, which will be classed among the grandest achievements of men, and the nearness of its completion, induce me to write this paper, which I hope will give some idea of its scope and purpose. I do not pretend to originality, as my work to some extent has been one of compilation from different monographs, which have appeared from time to time, and from some official publications of the Mexican government. I am indebted, also, to Mr. Farmer P. Gaston, and others for assistance.

The Valley of Mexico is an immense basin, of approximately circular shape with one extreme diameter of about sixty miles, completely bounded by high mountains, and having only two or three quite high passes out of it. No water drains out of the basin. The surface of this valley has a mean altitude above the sea of 7413 feet, and an area of about 2220 square miles.

Mountain ranges rise on every side, making a great corral of rock containing dozens of villages and hamlets with the ancient capital in the center. In times past the fires of volcanoes licked up the earth, and such fires still live in the mammoth Popocatapetl, from whose great maw sulphur fumes and smoke with jets of flame have poured through the centuries.

The valley thus hemmed in with solid walls of rock had been an inland sea for many cycles, and during the early existence of man here the salt waters spread over a large extent of the depression. The waters have been gradually lessening by seepage and evaporation, and the Aztec pilgrims coming from the north in the fourteenth century, having received a sign that they were to build their queen-of-the-world city on a small island of the sea, set about building dikes and combating the overflow of the waters. Many of their works remain to this day, and show that the valley was divided by them into five great departments. The dikes were built under the direction of King



HYDROGRAPHIC CHART OF THE VALLEY OF MEXICO—LOCATION OF THE DRAINAGE CANAL.

Netzahualcoyotl, a relative of the Emperor Moctezuma, whose surviving works prove him to have been an engineer whose conceptions and accomplishments would have given him high standing even among modern engineers.

One of the immense dikes he built was ten miles long. It divided Lake Texcoco into two parts. Of the two lakes thus formed one was allowed to remain salt, but the other was freshened by allowing only fresh water to enter by the streams flowing in, the water for the use of the city being taken from this latter. Little by little the waters have subsided since that period, and have been fought back, until now they are confined to six great lakes—Chalco, Xochimilco, Texcoco, Xaltocan, San Cristobal, and Zumpango. Each of these lakes is fed by streams which have little volume during the dry season, but which in the rainy season swell to considerable size, and at times overflow the valleys. The Lake of Zumpango was the most dangerous of these, for it received the waters of the Cuautitlan river,—a river draining a large area of country, and having during the rainy season a large volume of water. This river has been turned into the cut of Nochixtongo, and has ceased to threaten Mexico and its environs with its overflow.

From these topographical conditions frequent floodings of the old Aztec city end of the Spanish capital, situated almost at the lowest point of the valley, were sure to come in times of unusually heavy rains. In early days, when the Aztecs lived in the middle of Lake Mexico, when their temples and wigwams were built on piles and the streets were often only canals, the periodical overflows from the upper lakes were a matter of small concern, though even then the Nahua engineers were called upon to protect the city by dikes. But when by evaporation, by filling in at the site of the city, by lessened waters, due to the fissures caused by earthquakes, Lake Mexico had disappeared, and the city had come to be built on the spongy soil; above all, when the short-sighted choice of Cortez had been confirmed and the capital of New-Spain had come to stand on the ruins of the Aztec town, increasing rapidly in population and wealth,—it became a serious matter that on an average of once in twenty-five years the streets should be from two to six feet under water for an indefinite time.

Several times in the past, and centuries since the establishment of the city, the waters have been forced above their banks by freshets and floods from the hills; and although such events were not frequent, they nevertheless taught the dwellers in the town that in the waters lurked a constant menace to life and property. During the last great inundation in the seventeenth century the water stood at the level of the second story of the houses in the City of Mexico for several years, and even now the water marks of the flood which made the place into

HYDROGRAPHIC CHART OF THE VALLEY OF MEXICO—LOCATION OF THE DRAINAGE CANAL.

a western Venice are to be discerned. The removal of this danger from floods has been in the past a question of constant perplexity and debate.

Various attempts were made to remedy this condition of things, but nothing effective was accomplished until the early part of the seventeenth century, when plans were prepared for the building of a canal from Lake Zumpango to the foot of the mountains at Huehuetoca, thence a tunnel through the ridge over a league in length and nearly 15 feet wide by 12 in height, leading into a cut whence the river Tula was reached.

The cut of Nochixtongo was the result of this plan of tunneling for an escape of the waters, proposed by Enrico Martinez, a humble printer, early in the seventeenth century. After much indifference and delay his plan was finally approved in part, and he was put in charge of the work ; but he was sadly hampered by opposition and the changes made from his original design. Work on the tunnel of ten miles' length was commenced in November, 1607, and by working 15,000 Indians the task was completed in the almost incredible space of eleven months. Spain, engaged in armed debates with European enemies at this time, left no funds in Mexico for prosecuting public works. The tunnel was therefore completed with the least possible cost, and instead of being lined with masonry it was merely timbered after the fashion of "lagging" in a mine. On the waters from Zumpango, the highest lake, being turned through it, serious cavings in of the top and sides of the earthen exit very naturally resulted.

The problem was only partially and unsatisfactorily solved by this tunnel. In 1627 heavy rains caused the Cuautitlan to overflow into the lower lakes, and Mexico was left under eighteen inches of water. In 1629 the city was six feet under water, and remained so practically for four years. The question of moving the city to higher ground was then seriously considered. Fortunately, in 1634, an earthquake rent the valley and drew off the water, so that it was possible to fall back on the former plan of mending dikes and repairing the tunnel.

The tunnel was blocked up by this cause, and Martinez was cruelly scored for not having done his work aright by the very ones who had refused to give him the necessary material for it. He bravely essayed to repair the damage, but the water-soaked condition of the ground gave no resistance for the building of the needed walls, while death mowed down the enslaved workers. They were crushed to death by the frequent cavings in of the loose soil, or were sent to the grave by the deadly damps. Finally, the charge being made that the builder was blocking up the tunnel in revenge, he was thrown into prison, where he languished for many months. As there was no one else available who could carry on the great work, he was afterwards

released and again put in charge. It was then decided that, the tunnel being completely useless, the next thing to be done would be to make a great cut down to the tunnel and thus open it out. This entailed the making of an excavation fourteen miles in length with an average depth of 180 feet and width of 400 feet.

Martinez struggled on with this work for 37 years, and then died an unhonored death. All trace of his place of final rest was lost. The Spaniards continued the work in other hands for 150 years before the task of opening the cut was completed. Spasmodic work for a century and a half led at last to the accomplishment of this project in 1789. The old tunnel of Martinez is now a gigantic trench from 30 to 160 feet in depth and 300 feet broad in some places, and is known as the Tajo de Nochixtongo. The immediate vicinity of the workings was depopulated of its native inhabitants by the insatiable demands of the killing labor, and recruits were then drawn from Puebla and other thickly populated Indian centers. Great prison barracks were built on the bare hills, and here all the criminals were sent to enter the work. The ones in charge were indifferent with regard to the lives entrusted to their care, and the slaughter, of which scant record remains in the parish burial books, and which resulted from a combination of defects in appliances for both the safety and the comfort of the workmen, was terrific. As the burial trenches were filled with new dead, the depths of the cut were tenanted by new laborers.

The victims of three years of bondage numbered fully 200,000 ere the work was done. Yet the results were but slight, only the excess of water from the highest lakes and streams being carried off. However, the danger from inundation of the city has been very materially decreased by the Nochixtongo opening, and no more deluges have occurred since its completion.

Still the fact that the bottom of the cut was thirty feet higher than the surface of Texcoco, the lowest lying of the lakes, left the city in danger of inundation, as Lake Texcoco is constantly filling up at the rate of one and one-half inches a year and is now but a few feet below the level of the main plaza of the city.

The drainage works had long been a heavy burden upon the Mexican treasury. Up to 1637 Bancroft estimates that $3,000,000 had been expended. Up to the year 1800 the outlay had reached $6,247,670. Up to 1830 the total expenditure was $8,000,000.

The problem faced to-day by the Mexican government is very different from that which confronted Martinez in 1607. The question of preventing submergence is practically solved. The work of Martinez, unsatisfactory as it was, did a great deal to solve it. Since his day the area of the lakes has been gradually diminishing. The

rapid evaporation in the rarefied air and under the direct sun of the valley partly accounts for this. Twice the water in Lake Texcoco has almost entirely disappeared, leaving only a sea of mud and a small pool. The great problem which the Mexican government is now trying to solve is not how to prevent an inflow of water, but how to provide an outlet for sewerage. The danger now to be averted is not that of drowning, but that of dying from the plague.

Lake Texcoco more than any other now menaces the security of the capital. The unwise cutting down of forests since the Spanish conquest permits the waters pouring down into the valley to bring with them annually great quantities of alluvial matter, which have so much raised the lake bottom and the water level that inundations have been of frequent occurrence. The general level of the City of Mexico is only 6.56 feet above the surface of the lake. The rainy season lasts from June to October inclusive. During this season five times as much water falls as during the rest of the year, evaporation can no longer compensate for rainfall, and the valley is more or less flooded.

Originally built in the midst of a lake, the city has been left on dry ground by the receding waters. Lake Texcoco,—some three miles distant,—Chalco, and Xochimilco have altitudes nearly four feet greater than the pavement of the capital. Still more imperiously do the lakes to the north dominate the city. San Cristobal and Xaltocan are about five feet, while Zumpango is over thirteen feet, above it.

The project now almost completed is a modification of a scheme projected by Simon Mendez in the time of the Spanish government, and which in 1849 was adopted by Captain Smith of the corps of American engineers which accompanied General Scott's army. The tunnel was ultimately located under the saddle and through the ravine of Acatlan, its mouth being near the village of Tequixquiac. The works have been begun several times, and then suspended without effecting anything of importance. In 1866 the works now nearing completion were commenced. A project proposed by Señor Francisco de Garay, a well-known engineer of the City of Mexico, was pronounced the most feasible. But the revolutionary struggle succeeded, and for many years the work was relegated to the background.

In 1879 engineer Don Luis Espinosa, the present director of the works, took charge of the undertaking. In the first period mentioned the cutting of Tequixquiac was excavated, and the greater part of the shafts were begun; but at that point the work was stopped by political agitations. The work was really commenced in 1885, when the city council of Mexico submitted a project to the federal government, and offered to contribute largely to the cost.

President Porfirio Diaz then named a special commission with

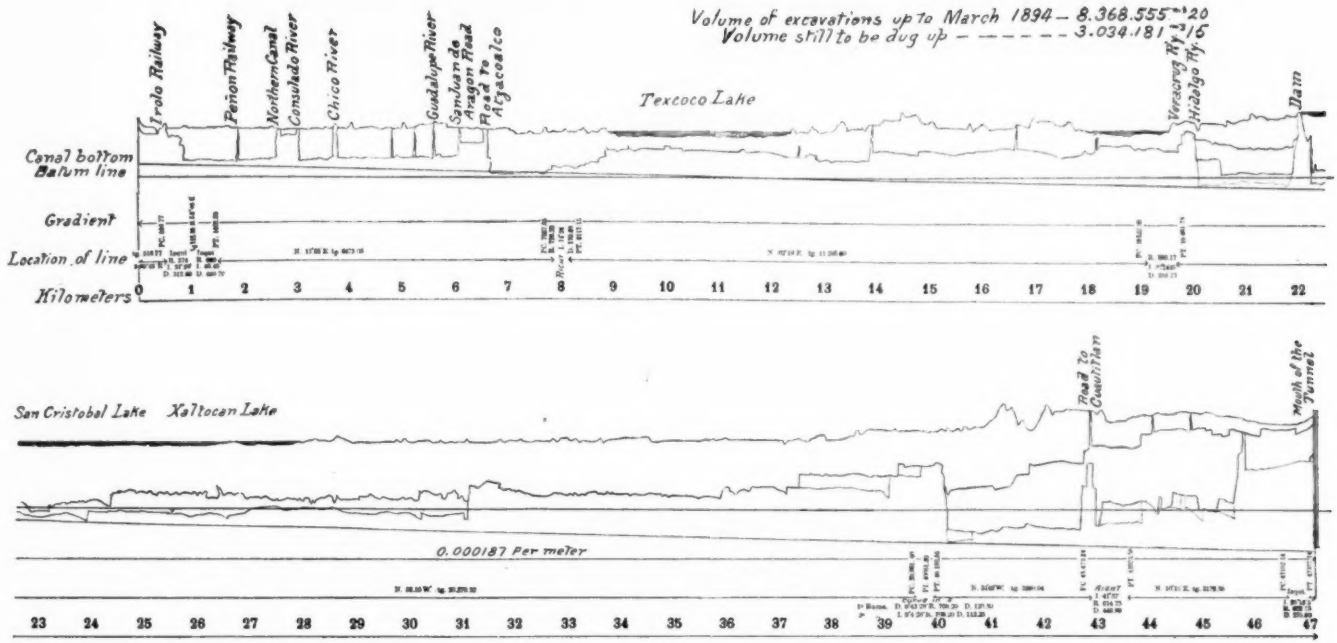
ample authority to disburse the funds dedicated to the work, and this body up to the present date has directed its execution. The sum of $400,000 per annum was placed at the disposal of the commission by the city council, and this amount was increased by the government to a sufficient sum. Two years later the city council contracted a loan in London of £2,400,000, the proceeds of which have served to meet the current cost of the work and to guarantee its successful issue.

The city council was able to assume the entire responsibility of the work, as the federal government ceded to it a part of the taxes to be collected, and authorized it to collect new taxes. Having expended the proceeds of the £2,400,000 loan without finishing the work, the Mexican government applied to its completion a portion of another federal loan of £3,000,000 recently negotiated in London.

The drainage works, when carried out, will receive the surplus waters and sewage of the City of Mexico and carry them outside of the valley, and will also control the entire waters of the valley, affording an outlet, whenever found necessary, to those which might otherwise overflow fields and towns, rendering the soil stagnant and marshy. The work consists of three parts—a canal starting from the gate of San Lazaro and having a length of 47.580 kilometers, its line following on the eastern side of the Guadalupe range of hills and between that range and Lake Texcoco, changing its direction after arriving at the 20th kilometer to a northeasterly direction, so as to diagonally cross Lake San Cristobal, a part of Lake Xaltocan, and a part of Lake Zumpango, and arriving finally at the mouth of the tunnel near the town of Zumpango.

The level of the bottom of the canal above the datum line adopted is 2.25 m. and the mouth of the tunnel is 9.20 m. below the same datum, supposed to pass 10 meters below the bottom of the Aztec calander stone. The level of the ground at the beginning of the canal is 8.94 m., and at the end 15.86 m., above datum. The uniform slope of the canal is at the rate of 0.187 per kilometer.

The canal has a depth, at its commencement, of 5.50 m., which in the last few kilometers is increased to 20.50 m. The side slopes were projected with a batter of 45 degrees, and the width of the bottom is 5.50 m. for the first 20 kilometers, and 6.50 in the rest of the canal. Referring to the map, the first 20 kilometers may be considered as a prolongation of the net of sewers in the city, and will receive only the water that passes through them. The flow is calculated for an average of 5 cubic meters, although, when heavy rains require it, they can receive a greater volume; the rest of the canal communicates with Lake Texcoco, and will be utilized in controlling its waters,—the low-


Volume of excavations up to March 1894 – 8.368.555 m³ 20
Volume still to be dug up – – – – – – 3.034.181 3/16
Irolo Railway
Peñon Railway
Northern Canal
Consuhdo River
Chico River
Guadalupe River
Samhan de Aragon Road to Atzacoalco
Texcoco Lake
Veracruz Ry
Hidalgo Ry.
Dam
Canal bottom Balum line
Gradient
Location of line
Kilometers
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
San Cristobal Lake
Xaltocan Lake
Road to Cuautitlan
Mouth of the Tunnel
0.000187 Per meter
23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47

SCALE

Horizontal..... $\frac{1}{50.000}$

Vertical..... $\frac{1}{400}$

DRAINAGE OF THE VALLEY OF MEXICO
LONGITUDINAL SECTION OF THE MAIN CANAL

est in the valley,—which can be made to flow into the canal from all parts. Hence the canal has been built to carry the largest flow that can pass through the tunnel, or 18 cubic meters per second. The cutting is through a strictly clay formation, comprising occasional thin strata of sand and sandstone.

For accommodation of railroads, wagon roads, and water courses it will be necessary to construct five aqueducts—four of masonry and one of iron—to carry rivers, four iron bridges for the passage of railroads, and 14 bridges for other roads.

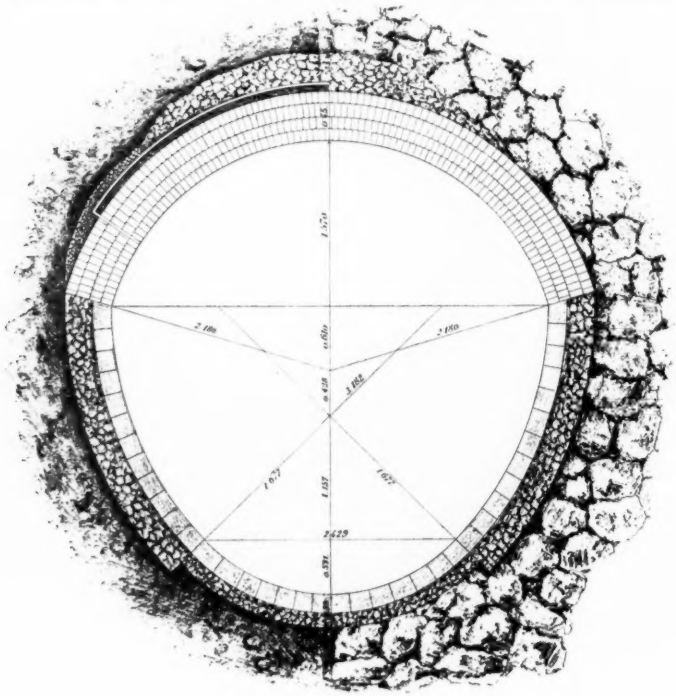
The sewers of the City of Mexico form a network of covered channels, located sometimes in the middle and sometimes on the sides of the streets, these being almost always gorges, communicating with a system of secondary sewers that empty into a collecting sewer discharging into the canal of San Lazaro, which transports the sewage to Lake Texcoco. If the water is high in the lake, water backs up into the sewers and saturates the soil under the houses and streets. As this has been the condition for several centuries, the state of the subsoil under the city can be better imagined than described. The death-rate touches 40 per 1000,—the highest in the civilized world. Mexico's elevation of over 7000 feet is all that saves it from a pestilence. Malarial and gastric fevers are almost continually epidemic.

For a century the problem has been settling into one of pure sanitation. The plans which the government has been working since about 1883, though called plans for draining the valley, really seek to get a fall sufficient to dispose of the sewage. In fact, in the original plan, from considerations of economy, care was to be taken to keep out of the projected canal all water both from the surface of the valley and from the rivers. The Consulado and the Guadalupe rivers were to be carried over the new canal in iron aqueducts. The drainage system was thus to be simply a part of the sewerage system of the city.

The excavated materials have been tipped on each side of the canal at their natural slopes, and a towpath near the canal level provided. Sluice gates will direct the city drainage either to the canal or to Lake Texcoco. A sluice gate at the junction of the smaller with the larger part of the canal will control the flow of Lake Texcoco, and another sluice will be placed at the entrance of the tunnel.

The tunnel has a length of 10,021.79 m., with a curved section formed by four curves respectively of the following dimensions. The upper part will have a span of 4.185 m. and a rise of 1.570 m.; the two lateral arches will have a chord each of 2.36 m., a radius with a chord of 2.429 m., and a rise of 0.521 m.; the elevation will be 4.286 m.; and the greatest width will be the span of the upper arch: the accompanying drawings show this section. The tunnel is lined

with brick, having a thickness in the upper part of 0.45 m., and in the lower part, over which the water will run, of 0.40 m. in the side arches and of 0.30 in the radius, this latter lining being of artificial stone, made of sand and Portland cement. The elevation of the invert at the beginning of the tunnel will be 9.20 m. below datum; at the end of the tunnel, 17.53 below datum. The gradient will be 0.00069 per meter for the first 2170.74 m., 0.00072 for the following 5831 m., 0.001 for 5100 m., and 0.00135 for the rest of the tunnel, these changes being in accordance with changes of details made from those of the original project, in some cases modifying the section and in other cases the lining. Twenty-five shafts each 2×3 meters were opened at a distance of 400 m. from each other. These served to ventilate the tunnel and to push the work. The deepest of these shafts, situated on the saddle of Acatlan, has a depth of 92 m.; the shallowest is 21 m. To give an idea of the labor involved beyond



SECTION OF THE TUNNEL.

the mere tunneling, I may mention that the quantity of materials required per lineal yard of tunnel was 1800 bricks, 94 cement blocks, 3 cubic yards of mortar, and 70 cubic feet of volcanic stone.

In May, 1894, the department of public works of Mexico contracted with Messrs. S. Pearson and Son of London for the completion of the canal, modifying former contracts of December 25, 1889, March 30, 1891, and April 18, 1893, under the following bases. The unfinished excavation in the first nine kilometers, and that between kilometer 47 and the entrance of the tunnel of Tequixquiac, are to be continued by the board of drainage directors, who must have the latter portion completed to 10 meters below the surface of the soil by December 31, 1894, and to the required depth of the canal by May 31, 1895, in order that the water in the canal may settle to that level and permit the contractors to slope the walls as required by the contract. The contractors are to complete the canal between kilometers 9 and 47 for the sum of $3,506,000. For making the monthly estimates the canal will be divided into two sections—kilometers 9 to 22 and kilometers 22 to 47. In the first section the provisional estimate will be 40 cents per cubic meter; in the second, a sum equal to the quotient obtained by dividing the remainder of the money by the number of cubic meters to be removed. The contractors may suspend the work of the dredges when they fall below 40 cubic meters per hour, and can proceed with the excavation in any way they wish. The excavation must be completed by May 1, 1896, except in the parts where the dredges cannot work. Then for each day's delay the contractors must pay $500 fine, and after five months the contract will be rescinded.

When the drainage board took charge of the work, it was executed by day labor both in the canal and in the tunnel, the latter having the larger amounts expended on it. But, shortly afterwards, the contract for the tunnel was let to Messrs. Read and Campbell, of London, who, after having invested a considerable sum in the work, found themselves under the necessity of cancelling their contract at the beginning of the year 1892. These gentlemen have continued to handle the work, but as managers, and under the direction of the board.

The excavation of the grand canal was originally contracted for by the Bucyrus Company of the United States, of which Colonel Harris, of Cleveland, was the president. This company brought two spoon dredges, capable of extracting up to 1000 cubic meters per day, and with these it commenced its excavations at the 22d kilometer. After the lapse of a few months, the board commissioners, desiring to push the work of excavation as much as possible, cancelled the contract with this company, and executed the one at present in force with the English contracting firm of Messrs. S. Pearson and Son, who have

undertaken to complete the canal by the month of September, 1895. These contractors are carrying out the work of the canal in two different ways,—by hand work with centrifugal pumps to draw off the water which filters into the work, and by means of enormously powerful Couloir dredgers which have a capacity for 3000 cubic meters of excavation per day, and which throw the excavated earth to a distance of more than 200 meters from the center of the canal. They have at present five of these dredgers at work, and by means of them can excavate to a depth of twenty meters, raising the earth to an elevation of more than 16 meters, so as to empty it into the shoots, along which it is carried by a stream of water that delivers it at a considerable distance from the dredger.

Sixteen months will see the opening of the great water way for the escape of the imprisoned floods of the valley, which in centuries past have been a constant menace to the city and its safety. The canal and six-mile tunnel through the mountain range have a total length approaching forty miles. The present works, when completed, will take rank with the great achievements of modern times, just as the immense "cut" of Nochixtongo, their unsuccessful predecessor, was the leader among ancient earthworks in all the world. The new tunnel is now complete, and light is shining from one end of it to the other. The completed system will have cost $20,000,000.

I have dealt with these works at some length, because their importance to the City of Mexico can hardly be overestimated. Instead of being one of the healthiest cities in the world, as it should be with its magnificent climate and situation, Mexico unfortunately has a terribly heavy death-rate, due principally to want of drainage and generally bad sanitary condition. When the existing danger of floods is removed, and the sanitary evils are remedied by a proper system of drainage, the increased security that will be enjoyed by life and property will certainly have its effect on the prosperity of the city. Property will rise in value, the population will grow with rapidity, not to mention the tide of tourists that will set in from the United States, and this will mean larger revenues for the municipality.

I could not well finish this paper without paying General Diaz, President of Mexico, a just tribute for the great interest he has taken in having this great work brought to a close during his administration. To his exertions in this regard and to his commanding position in Mexico, more than to anything else, this happy result, now almost in sight, is due. So after a weary search of centuries for relief, the beautiful valley of Mexico will gain its deliverance not only from the engulfing floods, but from the sanitary evils which have long resulted from defective drainage.

THE ARCHITECTURE OF MUNICIPAL BUILDINGS.

By E. C. Gardner.

MARLEY was dead to begin with. It is equally certain that our municipal architecture is bad,—which is about the same thing. In the case of Marley nobody but Scrooge cared to ask in what way he died, or why, or if he could be brought back to life. In the case of our architecture it is extremely desirable to discover in what its badness consists, why it has become bad, and then, if a reasonable solution of these questions can be found, to inquire still further how it can be restored to life and usefulness.

To plunge at once into the midst of things, no municipal building can claim architectural excellence which is not perfectly adapted to its site, to its use, to the number and dignity of the people who build it, to the length of time it is expected to exist, and to the influence it ought to exert upon the community in which it stands. Obviously a building suitable for a level plain will not be exactly fitted to crown a hill. It would be inexcusable to allow a school-house to present such an outward appearance that it might be mistaken for a jail, a factory, or a stable; or to give a distinctly ecclesiastical air to a city hall with its large family of most unecclesiastical civic offices; and what would be appropriate for a city of half a million inhabitants would be absurdly disproportioned to one of fifty thousand. To make false use of materials, to introduce frauds and cheap imitations, to temporize for the sake of saving to-day what will cost double to-morrow, to construct public buildings that, as long as they endure, will proclaim to friends and foes, to citizens and strangers, the vanity, parsimony, or ignorance of the people who build them,—all these things ought to be easily understood and avoided. And yet it would be difficult to find a city from Maine to California in which many of these architectural crimes have not been committed, and committed recently. In the past, poverty may have been urged as an excuse for some of them. But the most grievous faults are not the result of poverty. In fact, that stern master is sometimes as beneficent in its effect on municipal architecture as it is in the formation of human character,—preventing the growth and display of coarse and disastrous inclinations. There was also an excusable ignorance, the results of which may be winked at. But neither poverty nor ignorance can now be accepted in extenuation when a city allows a badly designed, badly planned, badly

constructed public edifice to disgrace its citizens. For it must not be forgotten that with our form of government every man, in proportion to his intelligence and activity, is responsible for all public achievements, including mistakes and failures in building.

Concerning the site for public buildings a fatal, because incurable, mistake is often made in their location, and more frequently still in the small amount of land appropriated. Leaving esthetic and sentimental considerations aside, it is simply common sense to say that for all usual municipal buildings the lot on which each one stands should be at least large enough to allow adequate natural lighting of the interior, whatever the height of the adjacent buildings may be; to afford ample and direct entrances to and exits from different parts of the building; and to preclude all annoyance from the ordinary use of the nearest streets. Fire-engine houses might be an exception to this rule, while for schoolhouses it would often be inadequate. Undoubtedly the city hall, which is, par excellence, *the* municipal building, should be as near the center of the city as possible; and, as land there is sure to be the most valuable, the tendency to keep the lot within narrow limits is inevitable. There are few cities that are not suffering from this mistaken economy on the part of the citizens, this want of courage and good judgment on the part of the city government.

The wise builders of the middle ages, and of the ages called "dark," liked to give their municipal halls room enough not merely for use, but for the display of their beauty of form and proportion. They seemed to understand better than we do that there is no architectural folly greater than placing a noble building where its wealth of beauty will be forever dimmed, if not wholly lost. It is surely a strange thing with our unlimited territory where every city (except New York) has a chance to grow and occupy all the room it pleases, if we cannot spare as much land for our municipal buildings as the closely built—and often walled—cities of the old world.

In large cities where space is exceedingly valuable the character of the ground is of comparatively small importance, except that the expense of making a solid bed of a treacherous bog or a bottomless quicksand must be added to the cost of the land. This is not the place to enter into the details of safe foundations, but it may be said that it would be difficult to find a piece of ground on which by the aid of engineering skill the heaviest kind of structure may not be placed in absolute security and permanence. (This point of fitness to its site is, so to speak, double-faced: before the building can suit the site, the site must be appropriate for the building.)

Adaptation to use includes, of course, the construction of the building, the arrangement of the floor plans, and the architectural ex-

pression, or style, of the exterior; and while these things would seem to need no argument, it is apparent that all three of them are oftener determined by tradition and the influence of bad examples than by intelligent radical study of actual needs. Some prevailing fashion, some fancied requirements of "effect" either within or without, some useless but long-established mannerism, leads to the continuation of faults that never had any excuse for existence. It would seem, for instance, to go without saying that school buildings in which from one hundred to a thousand children assemble once or twice a day, where they spend from one-third to one-half of their waking hours, should be arranged solely for their health, comfort, security, and enjoyment; that anything about the building which does not tend directly and openly to these ends is not only useless but offensive; likewise that the appearance of such buildings should to the greatest possible extent proclaim their motive and declare the dignity of their mission. And yet with all our professed love for free schools, and conviction that public education is the corner stone of our social and civil institutions,—in fact, of the nation itself,—there is often a vast inconsistency between our profession and our practice. Poorly lighted, badly ventilated, inconveniently arranged school-houses have been the rule rather than the exception until within a very few years. We have not been averse to making a cheap display of liberality, but the ruling passion to "reduce the taxes" not infrequently brings forth school-houses that suggest a cross between a cotton factory and

Town Hall, Middleburg, Holland.

Town Hall, Oudenarde, Belgium.

Town Hall, Siena, Italy.

CITY HALL, LEEDS.

a house of correction.

The only claim of fitness to their use in such buildings must be based on the notion that a public school is a place where learning is manufactured like beer in a brewery, while the passive recipients thereof are forcibly detained in order to receive their bitter discipline.

The city halls in which the audience of five hundred or five thousand, as the case may be, can see and hear in safety, in which the ventilation is not distinctly bad, in which the entrances and exits are safe, easy, and ample, in which the various offices are well lighted and conveniently arranged for the expeditious transaction of public business, and which are placed on large lots of land in the most convenient and suitable part of the city, are also few and far between.

HIGH SCHOOL, EDINBURGH.

A public building should be characteristic of the people who build it. Happily in this great republic of ours there are no such differences in rank or character that a type of building really appropriate for one city would be distinctly inappropriate for another of similar size, though there are minor differences that may well claim recognition. We have univer-

MANSION HOUSE, LONDON.

CITY HALL, PARIS.

CITY HALL, HAVRE.

CITY HALL, ANTWERP, BELGIUM.

PALACE OF THE PODESTA, BOLOGNA, ITALY.

sity towns, capitals of States, manufacturing and commercial cities, and those whose environment and interests are chiefly agricultural, as well as the great cities which are cosmopolitan in character. What is most perfectly adapted to one of these would not be equally suitable for either of the others.

Suitability to the length of time a building is intended to exist involves at once the question of materials. Not referring to the visible surfaces of the outer walls, there are but two, iron and clay; iron including steel, and clay including all kinds of bricks, tiles, terra-cotta, and cement. At the present time these are the only materials suitable for the essential structure of any building intended to endure a century or more. Under right conditions, both are indestructible by time and fire, and no one need be ignorant that the difference in cost between a building that cannot be burned and one that will dissolve in flames like frost before the rising sun is so slight that it would be no extravagance for the most impecunious cities to require all public buildings to be fireproof.

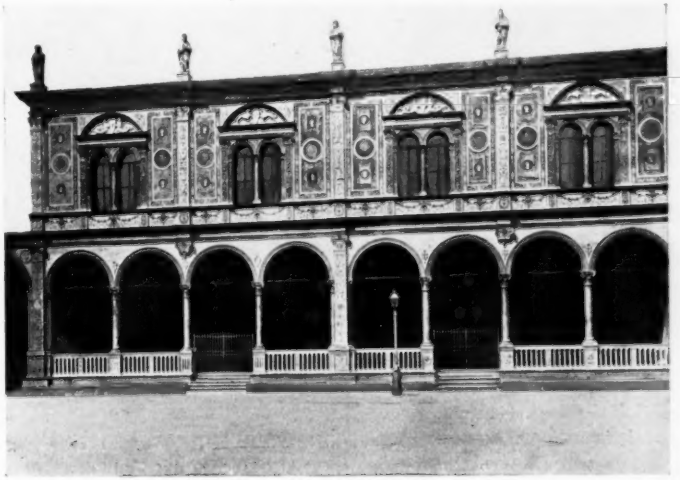
"Fire-proofing" the dangerous places, "slow burning" construction, and automatic sprinkling are well as far as they go; but guarding the dangerous places only drives the danger somewhere else, slow burning construction, like the traditional green wood, makes the hot-

test fire, when it does burn, and automatic sprinkling is liable to exercise its automatic instinct at the wrong time, so that after all there is nothing like using materials that neither time nor fire will destroy.

Surely a public building that can be destroyed in a night by conflagration lacks in a fatal degree the essential quality of fitness for long life.

Notwithstanding the rapid increase in the use of terra-cotta and the generally accepted recognition of its merits, it must be said that the modern product of our manufactures is an experiment to the extent that it has not yet withstood the test of time There are examples of terra-cotta hundreds if not thousands of years old that are apparently as perfect now as when made, but they were made in the good old times of honesty, not in the modern days of skill,—in adulteration,—and time still remains the only infallible test of the material. Yet there is such an overwhelming belief in its merits, it lends itself so readily to any desired effects of form and color, and is, withal, so moderate in cost, that it is impossible to avoid accepting it—risking it, if you please—as one of the most satisfactory of building materials.

The briefest reference to the building stones suitable for exterior walls would make a long article; and, though local pride may suggest that the home product should be used, if there is one, there may also be a national pride in our wonderful facilities for transportation, which make it possible to use whatever seems most desirable without incur-



PALACE OF THE COUNCIL, VERONA, ITALY.

CITY HALL, NEW YORK.

ring the charge of extravagance. One thing seems apparent: in many parts of the country we have become so accustomed to dark red bricks and darker brown-stone that we scarcely realize their somber effect.

When, in the consideration of this same quality, we reach the question of the influence on the community in which it stands, we enter upon sentimental and esthetic ground; but there is also a practical side. Improved methods of building as regards construction, utility, and economy are desirable: and, from the purely commercial point of view, it would be a wise investment for every city to erect at the public expense and as often as every two years some useful building which should be an object lesson illustrating the best methods of building. It is hardly necessary to refer to the fact that the municipal buildings of many cities, large and small, are amazingly impressive lessons of "how not to do it," stern teachers of things to be avoided in the matter of materials and workmanship, and in the business methods by which the work is executed.

It is a sign of cowardice or indolence to throw away everything that is tempting to thieves in order to avoid being plundered, and there is no more mistaken notion than that the liberal use of public

CITY HALL, ALBANY, N. Y.

funds is necessarily wasteful and must always be prevented. Stealing must be prevented, so must frauds and collusion with dishonest contractors and with architects who, by illicit commissions from dealers in materials or by special "arrangements" with contractors, are able to convince both the public and the servants of the public that the usual professional fees are unnecessarily high.

This brings us easily to our second inquiry—the causes of the bad-

TOWN HALL, NORTH EASTON, MASS.

ness of our municipal architecture. All things considered, the wonder is that it is not worse. Thorns and thistles do not produce grapes and figs at the end of the nineteenth century any more than they did at the beginning of the first, and there is no reason to expect visible improvement in the character of our municipal architecture while the present methods of obtaining and selecting plans for them prevail. It would be almost as reasonable to entrust the cutting and fitting of our clothes to the family butcher, on the ground that cutting is at least a part of his practice, that he has always been accustomed to wear clothes himself and has often observed them on other people, as to expect the average, or even the unusually intelligent, members of a city government to decide wisely on matters that require long, thorough, special training and experience. This is far from saying that the average city officials are not honest and able men in their respective vocations and professions; their ignorance of architecture is no reproach to them or evidence of unfitness for their office; the reproach lies in their willingness to judge for their cotemporaries and for posterity concerning matters of which they are necessarily ignorant. Even this willingness need not be ascribed to excessive conceit,—there is a certain percentage of modest men in all positions; it is the result of time-honored, or rather of time-dishonored practice. The difference between good and bad architecture is not only unperceived, it is not considered im-

portant. In the popular estimation excellence in this, the noblest, the most influential, the most enduring, and at the same time the most complex of all the arts, is a mere matter of fancy or of fashion, depending on familiarity or individual caprice. With by far the greater number of people who think of the subject at all, different forms and expressions in architecture, or what they suppose to be architecture, are thought beautiful for precisely the same reasons that the bonnets this year are considered more beautiful and becoming than those of last year. In neither case is there the slightest perception of any quality that is intrinsically and permanently beautiful.

And yet a thing of beauty is a joy forever, and we know that there is an architecture that has been not only an inspiration but a delight to all lovers of the beautiful; it has given world-wide and immortal fame to the people who created it and to the places where it stands; it has roused the patriotism, strengthened and sustained the public spirit, of the people who have dwelt within the light of its influence.

Allowing all details of sight, construction, sanitation, arrangement of floor plans, to be included in the legitimate scope of architecture,—a large allowance by the way,—there is no doubt that the sound judgment and common-sense which we have a right to predicate of those selected to transact public business may very properly be added to the skill of the architect, but these tithes of mint, anise, and cummin must not be esteemed above the weightier matters which alone give enduring value to architecture. It goes without saying that constructive skill and ingenuity in planning belong to every competent architect's equipment, but the "practical" architects who make a specialty of certain constructive methods, and claim superior ability in some one or more of the subordinate features of building, are not likely to attach a true value to the essential and enduring elements of architecture.

COURT HOUSE, SPRINGFIELD, MASS.

CITY LIBRARY, CAMBRIDGE, MASS.

In these piping times of competition, when towns and cities seem more anxious to grow by increasing the number rather than by improving the quality of their inhabitants, a common cause of architectural mediocrity or worse lies in the popular notion that "home talent" must be encouraged. If the results of this home talent in architecture passed away with the passing of its possessor, like the work of the merchant, the banker, the tailor, and the butcher, there would be less danger from this sentiment. Since the work of the architect remains as a permanent bane or blessing to an unlimited posterity, the shaping of such bequests becomes a grave responsibility, demanding something more than the accident of residence, which at most is but temporary.

So I repeat that the first step towards the improvement of municipal as of all other architecture will be the employment of competent architects, wherever they may be found; and second, the leaving of all questions of relative architectural merit to those who, by education, experience, refined esthetic instincts, and judicial quality, are competent to answer them wisely. I might add, and by eliminating politics from all public work; but when that happens we shall be ready for that realm where houses are not made with hands.

It is difficult to draw a line between utility and esthetic considerations. Indeed, it is mainly a matter of definitions. It is certain that

no public building is fit for its place whose visible form is not its own sufficient reason for existence. It must be complete and homogeneous; free from fantastic tricks and affectations. Whether it be Greek or Gothic, Romanesque, or some form of Renaissance, or of the style yet unborn which may some time be evolved, not from chaos but from the greatest and best that has been done in the past, it must be of a pure and distinct type. Freaks and aberrations have always been and always will be in private architecture. They have no place in buildings that represent the dignity, the permanence, the wisdom, and the wealth of an intelligent community, of a great municipal corporation; and any attempt to make the details of a building, or some curious and irrelevant excrescences, atone for or conceal inherent defects of form must always fail. A poor, misshapen clown cannot be converted into an Apollo by placing a helmet on his head and a lyre in his hands.

Doubtless the most serious faults of contemporary architecture arise from the lack of a clearly defined purpose, of a distinct recognition of the thing to be expressed, and then, when this is somewhat vaguely apprehended, of vacillation and uncertainty as to the best means of producing the desired effect. As in verbal expression, indistinctness, incoherency, and feebleness are commonly the result of indistinct, incoherent, and feeble thinking, so, until the scope and purpose of a public building—or of any other for that matter—stand out clearly in the minds of those who are to determine its form, there will be only incoherency and stammering in its utterance. One of the great charms of Richardson's work is that his trumpet gave no uncertain

PUBLIC LIBRARY, BOSTON.

sound. The same is true of the rich French and Flemish work. It is unmistakably Gothic and the same Gothic that we are accustomed to call ecclesiastical. Yet not for a moment would one mistake these buildings for churches. And it may be said here of all these illustrations that each in its way, and with more or less complete success, is an attempt to accomplish a distinct and beneficent purpose, in faithful accord with the conditions existing at the time it was built. They are not good because they are of one or another architectural style, but because through them men of practical skill and spiritual insight have clearly expressed a noble purpose.

Whether the city hall and the other public offices are under one

PUBLIC LIBRARY, QUINCY, MASS.

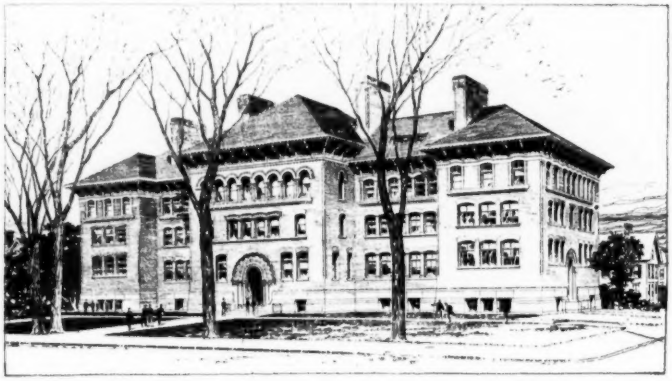
roof, or consist of a more or less detached group of buildings, they should have, at whatever cost to the city, spacious grounds, visible architecture of the highest type, and the best possible construction. For they reveal the public spirit, the general cultivation, the harmony of the citizens, and their ability to coöperate in good work, without which there can be no permanent and healthful growth. It is possible by good architecture to create such an enthusiasm that, instead of feeling that they are acting unwisely in appropriating money to add to the beauty of the city and enlarge its reputation for liberality and good taste, its citizens will rather desire to do more in the same

direction. Men in the mass are strikingly like the same men as individuals. They are willing to pay liberally for that which satisfies them, especially if it is admired by others; but they abhor being defrauded by dishonest and incompetent juries, architects, or contractors.

Generally speaking, the most satisfactory buildings, those which have held and are likely to hold the admiration of the world, regardless of time and place, may be grouped in three classes (I make this classification with some diffidence and ought, perhaps, to put it in the form of a question): first, those which, as to their exterior designs, are simply utilitarian in the common meaning of the term. That is, while certain parts may be exaggerated beyond the strict requirements

HIGH SCHOOL, CAMBRIDGE, MASS.

of use, the parts themselves are essential. There is no ornament, no attempt to give a decorative effect to any feature beyond what is obtained by a careful study of forms, by frank, natural composition and by well-chosen color. The second class would include buildings in which the main structure is utilitarian, but to which some distinctly monumental feature is added. This may be an ornate porch, a dominant gable, a cupola or dome rising from the roof, or a tower, more or less independent of the main building in its construction, and distinctly detached from it in significance; the building being rigidly adapted to its use, the tower as frankly serving a purely esthetic purpose. The third class would include buildings in which the whole,



HIGH SCHOOL, MALDEN, MASS.

while serving perfectly its legitimate use, is in appearance monumental; where no single feature is exalted above the rest, but where the entire visible building—roof, windows, and walls themselves—is treated decoratively, all its parts combining to produce one grand, harmonious whole.

To attach useless features and trivial decoration to a simple, unpretentious building indicates both vanity and poverty. It is infinitely better to let it remain in absolute and uncompromising simplicity. Having once decided to make a simple building, let us have the courage and wisdom to stick to it; having decided to give the simple building some feature of dignity and esthetic value, let us decide what that shall be, and avoid detracting from it by nervously attaching other minor features to divide its honors. What a fatal loss it would be to

DORMITORY OF THE STANFORD UNIVERSITY AT PALO ALTO, CALIFORNIA.

the beautiful Palazzo Publico of Sienna, or the Vecchio of Florence, if their stately towers could be made over into half a dozen minor turrets. Or suppose the central feature of the Hotel de Ville of Antwerp had been cut up into a variegated collection of insignificant dormers and pinnacles!

How to combine the utilitarian and the monumental without sacrificing either is one of the most serious problems in architecture. To make all our public arch tecture, whether simple or complex, whether utilitarian or monumental, of commanding dignity and grace is the duty laid upon those into whose hands the task is committed. For, more than any other material thing, its architecture fortifies and enriches a nation and indelibly records its history.

PLANNING THE SITE FOR A CITY.

By Lewis M. Haupt, C. E.

SO long as new territory remains to be developed, new centers of industry must spring up which may ultimately attain to the dignity of cities. But the projector of a town cannot always forecast the ultimate needs of the community with sufficient prescience to adapt his plans to them, nor is it often that he cares to do so, his main purpose being to realize quickly upon his resources.

New "town-sites" are not generally laid out by engineers or philanthropists who desire to secure the best possible results for all time, but by speculators who may never have seen the site—much less have had a topographic survey of it upon which to base the most economic plans for streets, grades, drainage, water-supply, sewerage, and the many other requirements of a large community. Often these elaborate paper projects cover marshes, dunes, terraces, or even inaccessible escarpments, but, so long as the demand for lots exists and the investor is willing to take the chances, it matters little to the "boomers" how serious the errors of location or design may be, or how greatly the cost of maintenance may be augmented by physical obstacles to habitation, transportation, or sanitation,—the three principal elements of a site. These mushroom cities are handicapped from the start, and it is not until some great fire or desolating pestilence teaches its lesson, that proper measures are taken to render the locality suitable for habitation.

A comparative study of the plans of existing cities, considered each with reference to the local topography, would prove interesting and instructive. The old fortified cities of continental Europe, with their walls of circumvallation, radial highways, moats, canals, and ditches present many and varied features of interest. Their location was often selected with reference to the strategic requirements of the times and the current methods of defense, but these considerations are not pertinent to the selection of suitable sites for and the proper planning of large cities in America to-day.

It should be considered, first of all, that certain sites can never be expected to support relatively large cities, while others, from the nature of their environments, can scarcely avoid having greatness thrust upon them. The presence of extensive mineral deposits is not in itself sufficient, but if there be a natural source of power, and, still more important, cheap, available transportation facilities, the prospects for a city are very good. But the best conditions exist where a large ton-

nage of any kind, especially of agricultural products, is transshipped and stored. Such conditions are presented where land and water systems of transportation meet, or at the head of navigation.

It should be noted that in the United States the great cities have followed the course of the Star of Empire and are on the western side of the waterways, as centers of distribution from the landings on the rivers and lakes. The area of the tributary territory accessible by water is also an important factor in determining the prospective size of a commercial center. Thus the phenomenal growth of Chicago is readily understood, and she has not yet attained the zenith of her glory, for the magnificent waterway now under construction connecting her port on Lake Michigan with the Illinois and Mississippi rivers will greatly stimulate her manufactures and increase her population. New York city, situated at the reëntrant angle of the Middle Bay on the Atlantic, has three-fourths of the circle of tributary (land) territory from which to draw her tonnage, and is therefore more favorably situated than any other tidewater point on the Atlantic coast. The Erie canal was the determining factor in raising her to the proud distinction of the American metropolis. She still needs increased interior deep-water communications to the south for coal and lumber and to the north for cereals and dairy products. If transportation facilities were equal, the "Zenith City of the Unsalted Seas" would have as good a *raison d'être* as Chicago, having the same water distance to traverse via the lakes to eastern ports, and an immensely productive territory from which to draw supplies; but the Chicago drainage canal will forever turn the scales in favor of the latter city, where, despite the marshes and lack of even sufficient slope for drainage, the imperative demands of commerce have determined the location of our western emporium.

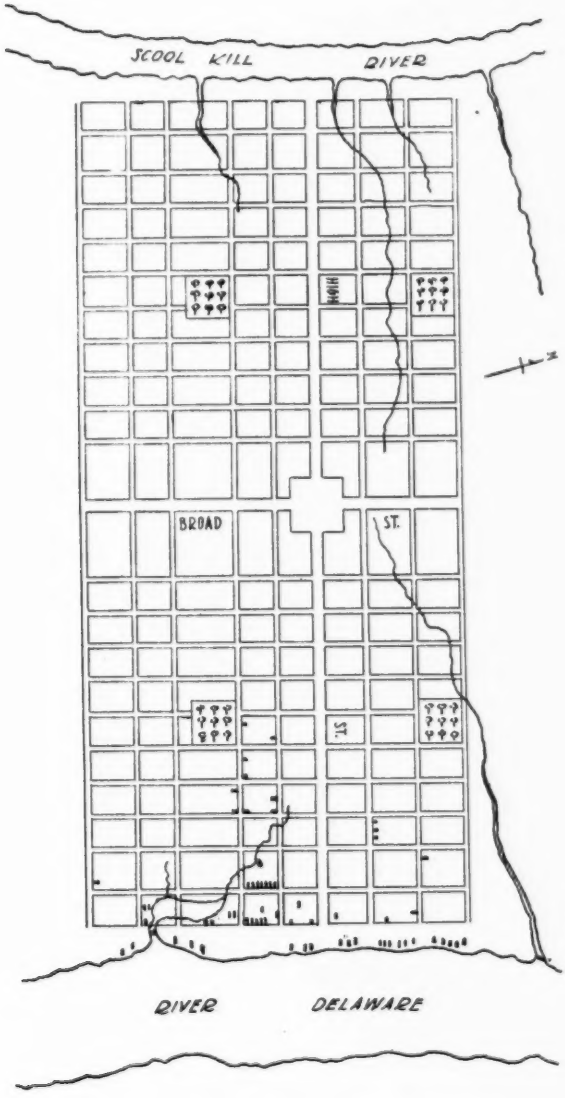
It is not difficult therefore to determine in advance whether the location proposed must be planned for a large, medium, or small population, and the designs may be modified accordingly by giving due weight to the geographical, topographical, geological, meteorological, and physical elements in the selection of a site. In this respect, while the northern latitudes have many favorable features, the ports on the Great Lakes are closed more than one-third of the year. On the other hand, while the southern ports on the Gulf of Mexico are open all the year, the high temperatures have hitherto prevented the storage of perishable freights, but the rapid increase of cold-storage warehouses is in a measure eliminating this objection. Taking all the conditions for the existence of a great city into consideration, it is believed that there is no locality better adapted to the development of a commercial metropolis than the northwestern angle of the coast of

the Gulf of Mexico. With the removal of the bar which separates the harbor from the commerce of the world, there will be a magical city springing up by the sea which should rival Venice in her palmiest days. The eastern cities are limited in their territory by the long-rail haul over numerous chains of mountains, so that the lines of least resistance for the trans-Mississippi region are either gulfward or lakeward. The early construction of the Nicaragua canal or the Tehuantepec ship railway, or both, will add weight to these suggestions as to the future of our gulf cities.

But it is not only the probable size of the city that should be considered in the nucleus of the plan. Its principal characteristic, as determined by the occupation of its inhabitants, is also an important element in the distribution of its population, and in the provision to be made for all kinds of service. Thus, for a commercial center, the greatest stress must be laid upon ample terminal facilities, warehouses, piers, elevators, and yardage, with convenient markets, exchanges, and chandlers, and accessible residence quarters. The conditions in a manufacturing town will be materially changed as to the character of the service and distribution of population, while for a capital or legislative center other plans are more suitable. All plans are largely influenced, however, by the local topography, and the prevailing mistake is made of placing the first highway parallel to some line of communication, be it common road, railroad, or water-course, and using this as a base from which to lay off a rectangular system of streets. This error requires grades which sometimes exceed 20 per cent. from the water frontage back to the plateau, and greatly restricts the commerce by adding to the terminal expenses as well as to the difficulties of laying and maintaining service-mains for the city.

Probably one of the earliest and best-considered attempts to plan for the future of a great city was that of William Penn in founding his colony on the Delaware. Although, in the two centuries which have elapsed, Philadelphia has far surpassed the most sanguine expectations of its projector, it still deservedly retains the distinction of being, *par excellence*, "The City of Homes." The wisdom and foresight of its founder are illustrated by these extracts from his instructions to his commissioners, William Crispin, John Bezar, and Nathaniel Allen:

> The creeks should be sounded on my side of Delaware river, especially Upland, in order to settle a great towne, and be sure to make your choice where it is most navigable, high, dry, and healthy. That is, where most ships may best ride, of deepest draught of water, if possible to load or unload at ye Bank or key side, without boating or litering it. . . .
>
> Such a place being found out for navigation, healthy scituation, and good soyle for provision, lay out ten thousand acres contiguous to it in the best manner you can, as the bounds and extent of the libertyes of the said towne. . . .



PLAN OF PHILADELPHIA, 1683.

Be sure to settle the figure of the Towne so as yt the streets hereafter may be uniforme downe to the Water from the Country bounds, lett ye place for the store house from the middle of the Key, wch will yet serve for market and State houses too . . . let the Houses be built in a line, or upon a line as much as may be. . . . The Distance of each House from the Creek or Harbor should in my judgt a measured quarter of a Mile, at least two hundred paces, because of building hereafter, streets downwards to ye Harbor.

Let every House be placed if the Person pleases in ye middle of its plat as to the breadth way of it so that there may be ground on each side, for Gardens or Orchards or fields, yt it may be a greene Country Towne, wch will never be burnt and alwayes be wholesome. I Judge yt you must be guided in yor breadth of Land by wt you can get yt is unplanted and will not be parted wth, but so far as I can guesse at this Distance me thinks in a Citty, each share to have fifty Poles (855 ft) upon ye Front to ye River, and ye rest Backward will be sufficient.

It would appear that Philadelphia was designed to be a commercial city, and that ample provision was made in Penn's plans for a comprehensive frontage. Unfortunately this rule has not been observed, and, now that it is proposed to expend about $8,000,000 in removing the obstructions to commerce and reconstructing the harbor front, the city is embarrassed by innumerable legal and physical obstacles, brought to bear by riparian owners. In reply to a question as to the rights of freeholders to build vaults in the high banks along the river front, William Penn wrote in 1684:

The bank is a top common, from end to end. The rest next the water, belongs to *front lot* men no more than *back lot* men.. The way bounds them. They may build stairs, and at the *top of the bank*, a *common exchange, or walk*, and against the street common wharfs may be built freely; but into the water, and the shore, is no purchasers.

In consequence, Philadelphia soon became the most prosperous commercial city of the continent, and maintained her supremacy until the opening of the waterways to the west, via the Erie canal, (in 1826) transferred it to New York.

As this river frontage was acquired by Stephen Girard, it will be of interest to note that in his will, dated February 16, 1830, he sets apart $500,000 for many public purposes and, *inter alia*, "to lay out, regulate, curb, light and pave a passage-way or street . . . fronting the river Delaware, not less than twenty-one feet wide, . . . to keep clean all docks, . . . to pull down all platforms carried out from the east part of the city over the river Delaware on piles or pillars." Yet this is the part of the frontage where the avenue is now to be widened to 150 feet and where "open" or pile piers are to be built over 500 feet in length. Such are the exigencies of commerce. Penn's plan, if followed, would have enabled the city to retain control of this magnificent franchise, to her great benefit and profit.

Another illustration from the history of our American cities is the carefully-matured plan that was prepared for the national capital. It

was laid out by Andrew Ellicott, C. E., after the plans of Major Pierre L'Enfant,* and one of the original prints may be seen among the relics filed in the Washington manor at Mount Vernon. The title reads: "Plan of the City of Washington, in the territory of Columbia, ceded by the States of Virginia and Maryland fo the U. S. of America, and by them established as the seat of Government after the year MDCCC. Engraved by Thackara and Vallance, Phila., 1792." This plan was the nucleus of the present city. The notes on its face read as follows:

> The grand avenues and such streets as lead immediately to public places are from 130 to 160 feet wide, and may be conveniently divided into footways, walks of trees, and carriage-way. The other streets are from 90 to 110 feet wide. In order to execute this plan Mr. Ellicott drew a true meridional line by celestial observation, which passes through the area intended for the Capitol; these lines he crossed by another, due east and west, which passes through the same area. These lines were accurately measured and made the basis on which the whole plan was executed. He ran all the lines by a transit instrument . . . and left nothing to the uncertainty of the compass.
>
> OBSERVATIONS EXPLANATORY OF THE PLAN.
>
> I. The positions for the different edifices, and for the several squares or areas of different shapes, as they are laid down, were first determined on the most advantageous ground, commanding the most extensive prospects and the better susceptible of such improvements as either use or ornament may hereafter call for.
>
> II. Lines or avenues of direct communication have been devised to connect the separate and most distant objects with the principal. Attention has been paid to the passing of those leading avenues over the most favorable ground for prospect and convenience.
>
> III. North and south lines intersected by those running due east and west make the distribution of the city into streets, squares, etc., and those lines have been so combined as to meet at certain given points with those divergent avenues so as to form on the spaces "first determined" the different squares or areas.†

Here then is a typical plan based upon topographic sites for the principal buildings, connected by "air" lines of ample width, and a

* The history of L'Enfant's plan becomes almost pathetic. Leaving France on the outbreak of the American revolution, he joined the Federal army and soon won the confidence of the Commander-in-chief for his courage and ability. After the close of the war he took up his abode in Philadelphia, and upon the cession of the District of Columbia to the United States as the seat of government, in 1791, General Washington appointed Major Pierre Charles L'Enfant to design the plan for the future capital. This he did with his usual skill, but on being requested to surrender his plan to the commissioners for publication, he declined on the ground that, if they were made public, speculators would select the best sites and build rookeries thereon, thus marring his ideal. He was accordingly relieved from the duty on March 1, 1792, and Andrew Ellicott, afterward geographer general of the United States, was appointed in his stead. Before the close of the year 1792 a new plan was prepared following as closely as might be the suggestions of L'Enfant, and the commission, at the President's suggestion, sent to the latter 500 guineas and a choice lot of ground for his former services. These he insolently declined, and the last years of his life he spent in haunting the lobbies of Congress, trying to secure compensation. He died in poverty about 1825 at a manor overlooking the site of the city, and was buried under a solitary cypress which marks his unhonored grave. (See "The Story of the City of Washington," by Todd, published by Putnam, 1889.)

† For these notes acknowledgment is due to Harrison H. Dodge, Superintendent of Mount Vernon.

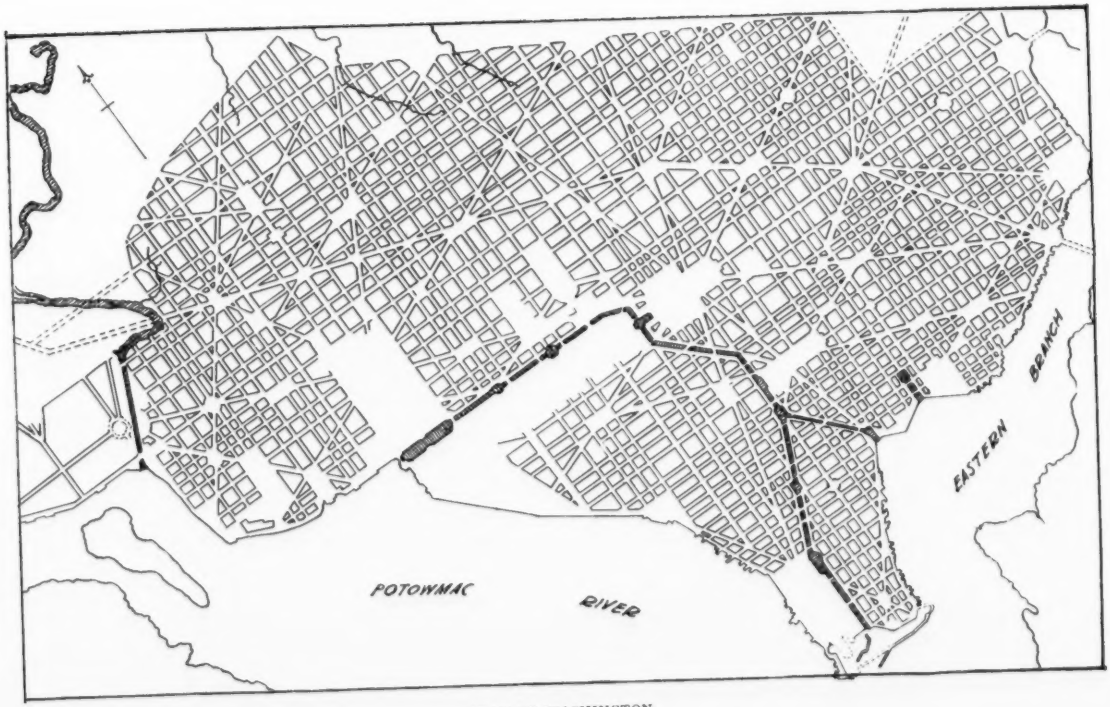
street system oriented on the true meridians, yet with a distinct purpose and no serious obstructions to the execution of the plan. Washington has ever been known as the city of "magnificent distances." Its reputed beauty is due largely to the complete revision of its grades and pavements under the régime of Alexander R. Shepherd, a quarter of a century ago, and its systematic prosecution by the District commission since that date. But while admirably adapted to the purposes of a national capital, the plan would be an unwarranted extravagance under ordinary municipal management. Few cities could afford to sacrifice 43 per cent. of their total area to street uses with the heavy expenses of maintenance. Great widths are not required for traffic or even for sanitation, the tendency being to neglect the untraveled portions, which in consequence become obnoxious. The "lungs" of the city had better be concentrated in squares or parks at frequent intervals and off the thoroughfares, leaving the streets to be designed only for their legitimate uses of traffic. Even for a large business, the best width for streets will be found to approximate to the four rods (66 feet) so common in our large western cities, although this is wider than is necessary for all streets. On the other hand, the boulevards, of which there may be a limited number, should exceed 100 feet.

The streets 50 feet wide as designed for Philadelphia by the proprietor are now found to be too narrow for the purposes of traffic since the city is gridironed by street-car tracks. These occupy the crown of each street, leaving less than nine feet clearance on either side between track and curbs and causing frequent obstructions. Yet in laying out new towns and villages in suburban districts fifty feet is thought to be a liberal width, while country roads are more frequently either two rods or thirty feet, with no provision for widening near cities.

The relative directions of the streets with reference to each other and to the meridian also merit consideration. The effort is too frequently made to locate the lines of travel on the cardinal points of the compass. The result is too great exposure to the sun in some quarters and not enough in others. The diagonal orientation, on the other hand, would provide a more equable distribution of the solar influences with better sanitary results.

Whether the blocks should be square or rectangular will depend upon the unit or size of the lot. Ordinarily the rectangle is considered the better plan, with a ratio of about 1 to 4 or 1 to 5 for the lot and 1 to 2 for the block; that is, the lots may average 25×100 or 125 feet, while the blocks may run 250×500 feet.

But these matters of detail are usually determined by the whim of the property-owner, whose interest it is to cut up the farm so as to produce the greatest revenue irrespective of adjacent requirements.



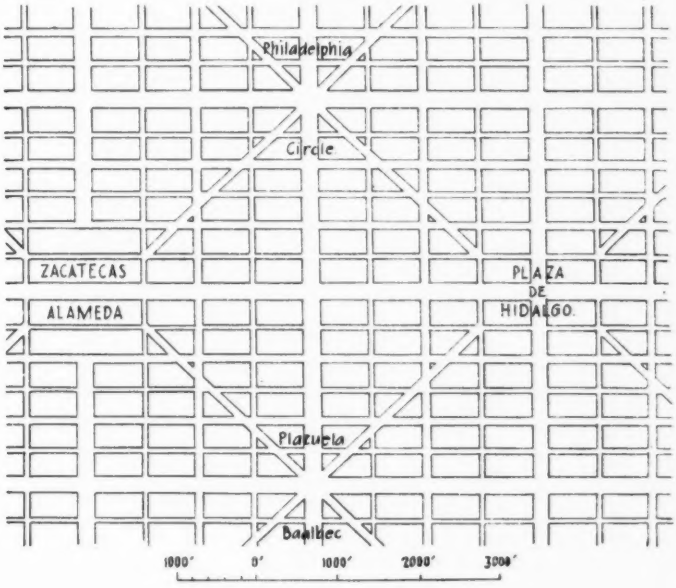
PLAN OF WASHINGTON.

Hence many new cities are mere aggregations of ill-conditioned and discordant suburbs, which, like "Topsy," had no training, but "just growed" to a congested maturity, burdensome either to endure or to remove. To prevent these labyrinthian appendages, in some western States, legal enactments now require each addition to be submitted to some central authority which must first approve of the plan and see that it accords with the adjacent plats in its general features. The full bearing of this point may be seen from an inspection of an atlas of almost any rapidly-growing suburban town in one of the older States, the several land-owners having been at liberty to divide up their properties at will. It will be noted that the streets are short disconnected passage-ways, and that their total length is greater than would be required for a much better service on a preconceived general design. The maintenance of this abortion imposes unnecessary expense upon the town for all time, and, although the original owner may secure a few more dollars for his tract, he has in the aggregate to construct and maintain a greater length of streets. This is generally done in the cheapest and most primitive way and with little or no provision for drainage or water-supply, until these heterogeneous plats are incorporated into a borough or town, when the taxpayer must pay a higher rate to maintain or correct the errors of grade alignment, drainage, and other municipal service.

Concerning the distribution of the population, where it is homogeneous and does not exceed the sanitary limit of 100 per acre, there is no necessity for any other than a rectangular system of streets, if the town is always to remain limited in size,—to, say, one square mile or 64,000 population. But when it runs up to the hundreds of thousands, it is evident that numerous convergent avenues must be provided from different centers to meet the enlarged requirements of travel. Upon this sanitary basis, with five to a family, and but one family to a residence, there would result twenty lots to the acre, and, if 33 per cent. be taken for street areas, there will be left 29,040 square feet for the twenty lots, giving an average of 1452 square feet, or lots 15×96.7 feet, a size small enough for the most avaricious. This, however, is for the greatest permissible density of population, and is a limit which is seldom adopted. Under this limitation a city of 1,000,000 inhabitants would require 10,000 acres, or 15.6 square miles—a tract nearly four miles square—with diagonals of 5.6 miles. Unless such diagonals were provided in the original plan, it would require a space of eight miles to be paved in moving from one corner to the opposite diagonal. Such divergent or radial lines would increase the available assessable frontages more than they would diminish the available building area, and are therefore fully warranted public improvements, for

which provision should be made on the best topographic lines in the location and orientation of a large city.

The ideal design of Gonzalez City, on the bay of Topolobampo, Gulf of California, furnishes an illustration of variations in width and directions of streets with numerous plazas, alamedas, and rondos, but laid out with a geometric regularity which can scarcely adapt itself economically to an extended terrane. The parks also are too numerous and extensive, and interrupt the continuity of some of the principal avenues.



PLAN OF GONZALEZ CITY.

In the old portion of the city of St. Paul, Minnesota, will be seen an abnormal outgrowth of circumstances, where near the "Seven Corners" the street named Second runs into Third, while Third intersects and extends across Fourth, cuts Fifth at its terminus, and is parallel to part of Sixth. So in one place the numbers of the streets taken consecutively read Third, Fourth, Fifth, Seventh, Sixth, Ninth, and Tenth, with no Eighth street. The topography of the site is peculiar, as it rises in three terraces from the flats and is intersected by a ravine which enables the railroads to pass from the river bank to the

plateau. The variations in lots and blocks of the numerous additions are shown on the small section of the map selected as a type.

It is impossible to enter here upon a minute analysis of the numerous types of city development, or to elaborate upon the enormous expenditures required to overcome their original defects. It is a mat-

PLAN OF ST. PAUL.

ter of more moment to a city that her plan should be carefully adapted to the topography, and the physical obstructions to urban traffic be removed, than that similar care and skill be bestowed upon the location of a railroad or other communication with outlying districts. Hence we are forced to the conclusion that, the size and location having been

determined, the form or direction of growth must be governed largely by local physical conditions. The presence of a commercial frontage will manifest itself by a prolongation along the water. Thus Chicago has a length of twenty-four miles and a depth of only eight miles. Manhattan Island is about 13½ miles long and two wide, giving about twenty-eight miles of frontage.

It will be seen that no absolute rules can be laid down, but that the topography must exercise the predominating influence and suggest the plan. If the site selected does not lend itself naturally to a rectilinear plan with occasional diagonal thoroughfares, then the curvilinear or angular, divergent or serpentine may be adopted, if, by so doing, distances may be reduced and grades (except for drainage) be avoided. By all means the formation of towns and cities by the aggregations of individual plats laid out to suit the owner should be avoided even by prohibitory legislation.

There exists to day in all civilized countries a strong tendency towards concentration in social and business centers, and the effect is manifest in the rapid growth of cities by the removal thereto of the rural population. Wherever favorable conditions exist, there will be found springing up a hamlet, borough, village, or town which in a few decades may expand to the dimensions of a city.

In any event, provision should be made both in the selection of the site and in the preparation of the plan of such a nucleus for its ultimate expansion, and much will be saved if the advice of some competent engineer be solicited in advance as to both these points. Even the character of the soil upon which a town may be built plays an important part in the sanitary condition of its inhabitants.

The purity and cost of its water supply as well as the facilities for sewage disposal are also functions of the site which should be selected so that these may be provided for, to a large extent, at least, by gravity, and without contamination of the streams serving other localities. Hence the desirability of professional advice.

THE SELECTION OF MOTIVE POWER.

(FIRST PAPER.)

By Charles E. Emery, Ph. D.

IN selecting a motive power for a new manufactory a prudent manager would naturally inquire if there were any new developments on the subject, and ask as to the relative standing of well-known means in view of modern improvements. The inquiry cannot be limited to apparatus required for a particular purpose, subject to the conditions which obtain at a particular place, but must indicate the principles of selection for differing conditions, and may even involve the examination of a location with reference to its advantages for obtaining not only power, but suitable labor and accessible markets. The subject is, therefore, necessarily approached in a general way. We should at first realize that all power in sufficient quantities for manufacturing purposes is obtained by utilizing in some way one or more of the various forces of nature. The energy of the sun expended in lifting the vapor of water to the clouds is returned and in part utilized by man as the aggregated rain drops find their way in the streams from the slopes to the sea. To the same source of energy the changeful winds owe almost exclusively the motion and force familiarly utilized on sea and land. Even the heat derived by burning the trees of the forest represents a portion of the energy of the sun, which has changed inorganic incombustible matter into organized combustible tissue and fiber, and thereby stored up energy in the past for use in the present. It is more important than all to recollect that this operation has been going on for ages, and that our coal fields and supplies of mineral oil represent also the energy of the sun stored in prehistoric vegetation buried in the earth and transformed in the laboratory of nature. Abstractly, then, the question is whether we shall derive our motive power from the sunlight of the present or from that of the past. A prominent distinction at once appears. All direct forces from the sun now available, whether they be from the winds or the waters, are of the varying character familiar in everyday life; whereas energy stored, whether in the form of coal, mineral oil, or even wood fiber, can be expended to produce heat and power at will. On the same principle the varying forces derived from water can be better utilized by the various familiar systems of storage. It would appear, then, from considerations of a very general nature, that the most reliable power must be secured from mineral fuel, consumed at will, and the power next in reliability, from water stored in great natural reservoirs.

The power derived from the fuel must in general be obtained from a heat engine, of which the steam-engine is the most familiar type and that most generally employed. The steam-engine has therefore become the standard to which the cost of all sources of power are referred, although in special locations power may be obtained more cheaply in another way.

Water is a primary source of power, as the potential energy due to its elevation may be directly transmitted into mechanical work. Steam is, however, a secondary source, as it is only a means of transmuting into mechanical work the energy stored in the fuel and available as heat. Both primary and secondary sources may easily be confused with mere means of transmission. Electricity is not a source of power. It may be made a secondary source in the same sense as steam, by the discovery of a practical method of generating it on a large scale from the direct combustion of fuel. At present it is only a means of furnishing at one point power developed at another, and in this respect stands in the same category as hydraulic and compressed air transmissions, and, except for some purposes relating to the distance covered, acts on the same principle as transmission by wire ropes, belts, or ordinary shafting. Every means of transmission must be operated by a true source of power, like a steam-engine or a water-wheel, and in the abstract, where the greatest efficiency is obtained, the efficiency is higher the less the number of parts interposed between the source of power and the point where the same is utilized. Transmission of steam is distinguished from the above by the fact that it permits the boilers to be located at a convenient point and the steam to be used where heat or power are required.

Approaching the details of the subject, we first call attention to the fact that the power available by the use of windmills is by no means small or valueless. They make the continuous drainage of the lowlands of Holland practicable, and mills requiring 80 horse-power and upwards are successfully operated by a single wheel. The system is not, however, well adapted for locations where the wind is light and variable and where coal is as cheap as in most locations in this country. In some places along the coast the wind blows so much of the time, and so strongly in one direction, that isolated trees lean away from it and are distorted by having foliage principally on the leeward side. These living wind vanes clearly point out the possibility of using windmills for power in such localities. There are many things, however, to think of before making such an installation. In the best location the wind is liable to fail at inopportune times, and a given output can only be obtained by frequently working during the night. Such a system would therefore not be popular where the general feeling

of labor organizations, and indeed of all wage-earners, leans towards a definite number of hours of labor and a definite output in proportion thereto, with the remainder of the day available for social enjoyment or mutual improvement. Where the labor can be changed from one place to another, as on a farm, windmills are very useful, and particularly where fuel is scarce. The windmill manufacturers make many sales in the West and other parts of the country where the conditions warrant the use of such a power. Windmills as we know them in this vicinity are chiefly used for pumping water, and, being of the American automatic type, care for themselves under all possible varying conditions; and although water is pumped only when there is sufficient wind, it is stored in tanks and thus made available for use when the wheel is at rest. Competition has made this type surprisingly cheap. Mr. Brush, the electrician, constructed at his country-seat an experimental plant in which a windmill was used to generate electric current and charge storage batteries from which such current was utilized about the premises. This system has recently been suggested by others for general use, and should be feasible and possibly profitable in favored locations if operated on a sufficiently large scale to warrant the employment of the skilled labor necessary to keep in order the batteries and other apparatus, particularly the several automatic devices necessary to practically convert a changeable source of supply into energy available continuously.

Leaving the general question of water power until it can be conveniently compared with steam power, we will examine the availability of heat engines other than steam-engines Hot-air engines have not come into general use for miscellaneous power purposes. They are practicable on a large scale by the use of temperatures and pressures so high as to prohibit in a sense general use. There are, however, some small engines largely used for pumping purposes which work within such reasonable limits as to give little or no trouble. The original form is that designed by Ericsson. In the base of the apparatus a small fire of gas or coal is kept burning and heats directly a shell pendent from a cylinder containing a piston with pendent plunger, between which and the hot bottom cold air is forced as the plunger rises, which, being heated, completes the upstroke, when an exhaust valve opens, the plunger is returned by the action of a fly-wheel, and the operation is repeated. The Rider hot-air engines operate successfully on a very similar principle, but with entirely different details. Both these forms of engines are used by ordinary help to pump water from the street mains to an elevated tank. There is no possibility of an explosion, and the danger of overheating is entirely prevented if the operator once gets the pump started, for then any extra heat only increases the speed.

Gas and petroleum engines of various kinds are largely used for power purposes. In one form of the latter, used largely in naphtha launches, naphtha stored in tanks on the vessel is injected into a coil heated by a naphtha lamp, and the resulting naphtha vapor is used in a small engine like a steam-engine. Generally, however, naphtha or crude petroleum is sprayed directly into the cylinder of an engine, where it is vaporized by the heat, when the operation is the same as in a gas-engine,—viz., the vapor or gas is mixed with air and exploded by a fixed torch, causing intense pressure utilized on a piston, and a high temperature controlled by a water jacket. Gas and petroleum engines have some advantages for detached locations, where they receive only the occasional attention of careful but unskilled labor, as the operations are all automatic. A comparatively small quantity of naphtha or oil is placed in a tank at the base of the petroleum engine, and, with the same reasonable care that would be exercised in handling petroleum for lamps, there is little danger of fire. In general, the larger quantities of oil are stored outside in underground tanks, and in some cases it is provided that no store is kept about the engine, but the quantity required for each stroke is withdrawn from the tank outside by means of a pump. Where gas is available from a street supply, the installation of a gas-engine is simpler than that of a petroleum engine, as it only requires a pipe connection to the gas service; otherwise the two forms of engine are generally very similar in appearance, construction, and operation. There is some jar and noise due to the explosions, which must be provided for in locating the engine in dwellings. Generally by bedding the engine on soft earth or sand, without permitting any connection of the same to touch the walls or a common rock foundation, the noise and jar will not be communicated so as to cause annoyance. Prof. Elihu Thomson has installed a petroleum engine built by one of his companies, affiliating with the General Electric company, for generating electric lights for his home at Swampscott. The cost is found to be somewhat less than would be required for a steam-engine of small power, though greater than that of power derived from steam machinery of large size. It should be remembered by those desiring small power for use about a country house that every form of apparatus for furnishing the same is liable at times to special derangements and requires occasionally skilled adjustment and attention, so that annoyance, when ordinary labor is employed is sure to come sooner or later, and the selection of a motor in such a location is therefore in some respects a choice of evils. The difficulty is largely diminished if the owner himself will take pains to familiarize himself with principles and details so as to know what should be done in an emergency. If he, therefore, takes the place of

a skilled engineer, the particular kind and style of motor should be one which he believes adapted for the purpose, and will therefore care for in the most efficient way. The same principles are applicable in selecting power for a small factory.

There is, however, a field for gas-engines where a supply of ordinary illuminating gas is not available. There has been in operation in England for a number of years a system in which gas is generated in a "producer" resembling that used in steel and other furnaces. The principle is that of heating a quantity of coal in a simple cylindrical vessel by admitting only a sufficient quantity of air to produce imperfect combustion. The effect is to drive off with the waste gases carbonic oxid gas, which is combustible, mingled with hydrocarbon gas if the coal is of the bituminous variety. The mixture, called "producer gas," is used in a gas-engine having the general features above described. Plants of this kind have been installed of from 25 up to 400 horse-power, and are said to operate efficiently. The economy of small gas-engines under experimental conditions is considerably greater than that obtainable with an ordinary steam-engine, a result as low as 1½ pounds of coal per indicated horse-power per hour being claimed by the manufacturers. Comparing this system with a steam-engine, it will be seen that the producer in a sense takes the place of a steam boiler, that producer gas is employed instead of steam, and that a distinctive gas-engine is required instead of a steam-engine. The number of parts necessary to do the work is therefore not varied, and the number of transformations is the same. In the steam-engine the heat of the fire is imparted to water, and the water used in the engine. In the gas-engine a part of the heat of the fuel is used to produce the gas, and the explosion of a mixture of the latter with air produces the power. The gas-engine is theoretically the more economical, simply because fixed gases are employed and operation depends largely on variations of temperature or changes of sensible heat; whereas with steam a certain quantity of latent heat must be imparted to the water to form steam, and is retained in order to maintain the water in the state of vapor when the exhaust takes place. In practice care must be taken to keep up a regular action of the producer so as to supply a uniform quality of gas. On account of the difficulty in doing this, it is believed that the economy obtained in practice is not always in excess of that of the steam-engine. The want of uniformity of the gas applies to large as well as small gas apparatus, whereas steam in large quantities can be generated and utilized continuously under conditions of maximum efficiency. It does not appear, therefore, that gas-engines and accessories can as yet compete on equal terms with large steam-engines in their present perfected condition. The wear and

tear of gas engines are, moreover, necessarily greater than those of steam-engines.

There is a future, however, for gas-engines by generating producer-gas cheaply at the mines, using even the waste coal for the purpose, and piping such gas to a long distance to operate gas engines in the way described. A modification has been proposed in England in which the gas-engines were to be operated in the immediate vicinity of the mines to generate electricity which would be conveyed to long distances for power and even heating purposes. The prospectus of this scheme showed a very large saving compared with using fuel in the ordinary way. With all due allowances for the claims of sanguine inventors and promoters, it is believed that something will be accomplished along these general lines within a reasonable period.

The advantages of the steam-engine where fuel is reasonably cheap need not be strongly urged. Its use has been extended so rapidly as to make it an important factor in the growing civilization and prosperity of mankind since the days of Watt. It can be employed anywhere that fire can be permitted, in quantities small or large; the power is readily controlled, and the apparatus in all details easily handled by all persons of intelligence after a reasonable preliminary education and experience. It has been so tested by long practice that the details of construction for engines of the same type made by different manufacturers are substantially identical, and, though there are good and bad features among the the so-called improvements, they are of too varied and technical a nature to be treated in this article, and the services of an engineer are necessary to point them out. We can only call attention to the advantages of several distinguishing types of steam machinery. First, as to boilers: the plain vertical tubular is best for small power and particularly for semi-portable engines; the more expensive locomotive boiler is best for self-propelling portable engines; and the horizontal tubular boiler set in brickwork is in some respects best for general factory purposes, the sizes being fixed by the pressure to be carried and the power provided for by duplication. These boilers do so well that parties get in the way of thinking they will take care of themselves, and occasionally disastrous explosions occur.

There is therefore a growing preference for the so-called "safety" boilers, constructed principally of water tubes and connecting vessels of small size with a very large surplus strength, or, as it is called, a large "factor of safety." It is not proper in this article to attempt to discriminate between the different kinds of boiler of this type. In making a selection the question of reliability under conditions of actual and long-continued service should be considered, rather than mere differences of cost. Engines are in general distinguished as

follows: "non-condensing engines," from which the steam is delivered into the atmosphere or into a low-pressure heating system; "condensing engines," from which the steam is condensed either by admitting cold water to a separate vessel or by precipitating the steam upon surfaces kept at a low temperature by circulating water, or in some cases by large volumes of air; "compound engines," in which the steam is worked serially through one or more cylinders increasing in size so as to secure expansion and reduce internal cylinder condensation. Such engines are called "simple compound engines" when there are two cylinders in series, "triple compound engines" when there are three such cylinders, and "quadruple compound engines" when there are four such cylinders, etc. In contradistinction to the above, non-compound engines are frequently called "simple engines." Engines of less than 50 horse-power are generally simple non-condensing engines. Non-condensing engines of larger size are also employed where it is difficult to obtain condensing water or where the exhaust steam can be used for the purpose of heating buildings or the various fluids required in dyeing or other manufacturing processes. Simple condensing engines are rarely made of less than 75 horse-power, and more customarily are of 125 horse-power and upward. Until quite recently they were used universally for factory purposes, single cylinders being employed up to 250 and occasionally 500 horse-power, and for larger engines two cylinders were employed, doubling the power. To provide a reasonable amount of steam for heating and other purposes about the factory, it was not uncommon to make one end of one of the cylinders non-condensing, by the use of a separate exhaust pipe quite readily arranged with engines of the Corliss type. Of late, such engines are only used where coal is comparatively cheap, and compound engines are employed in their stead, a small cylinder being arranged behind a large one for a single engine, and the same arrangement duplicated for a double engine; or, one of the cylinders of the double engine is made larger than the other and the exhaust taken across from the smaller to the larger, making what is termed a "cross-compound engine." When reasonable quantities of steam are required for various heating purposes in a factory using this kind of engine, it is customary to take the steam supply for heating from the intermediate chamber between the two cylinders, thus reducing to that extent the power of the larger cylinder only. The steam pressure employed for these three types of engines is about the same, or from 80 to 100 pounds. With the more general introduction of the compound engine the pressure has been raised to 125, 150, and 160 pounds. As it became practicable to use boilers adapted for higher pressures, a number of triple compound engines have been intro-

duced, operated in some cases with pressures the same as for simple compound engines, but some plants have been built to use a steam pressure of 200 pounds.

The advantages of high-speed engines were pointed out by Mr. Chas. T. Porter years ago, and many engines of the Porter-Allen type have been constructed. The system was not, however, generally extended until after the experiments of the writer at the Novelty Iron Works in 1868, which showed that a high speed of revolution had the effect of reducing cylinder condensation. The adaptation to this type of engine by Mr. J. C. Hoadley, of a governor located in the fly-wheel, operating to move an eccentric transversely across the shaft and thus produce variable expansion with a single lap valve, had the effect of making these engines govern excellently and show a fair efficiency with a very simple construction. Small engines of this type are frequently run up to from 250 to 350 revolutions per minute, and, although their weight is much greater than for the same size of cylinder with ordinary engines, they still contain less material than slow-speed engines developing the same power; so the high-speed engines can be furnished for less first cost, and have become quite popular for many purposes, particularly for small electric lighting plants. Manufacturers are frequently tempted to select this type of engine on account of its comparatively low price. Such engines are, however, made for hard service with simple details and ample clearances, and the valve gear, though efficient, does not generally give as good results as that used on slow-speed engines. The consequence is that the high-speed engines, as a rule, are not as economical as slow-speed engines. Moreover, on account of the high speed, though very carefully constructed, they generally require more careful attention. In some forms, features of automatic lubrication have largely eliminated the difficulty, but results show that, if from neglect a journal heats, the temperature rises more rapidly and is therefore more destructive on the average with a high-speed engine than with a low.

The success of high-speed engines has led to increasing the speed of forms previously known as slow-speed engines, with very advantageous results. It is found, for instance, that it is practicable to operate a Corliss engine of 42″ stroke at 100 revolutions per minute, giving a piston speed of 700 feet per minute. Similar engines of 5 feet stroke have been run up to 80 revolutions per minute, giving a piston speed of 800 feet per minute. Such engines work satisfactorily, and seem to require little more attention than larger engines developing the same power.

PLUMBING TRADE SCHOOLS AND THEIR INFLUENCE.

By E. N. G. Le Bois.

FOR reasons that are not far to seek, plumbing has not heretofore ranked high in honor among the handicrafts, and it must be admitted the plumber in the years that have gone, did much to bring upon himself the obloquy that so generally attaches to him. The perennial jokes of the newspapers that ring every conceivable change upon his jewelry, his incapacity, his cupidity, his slovenliness, and his general Ishmaelitism, tell the story of shortcomings that have been apparent at one time or another in one individual or many. His misdeeds are ever the subject of jest, but the time is not far distant when the delinquencies of his professional childhood will be kept no longer in remembrance, and he will attain to the honor and dignity that the importance of his work deserves. His case has many parallels in the rise from popular contempt of other professions which are now looked upon with high regard. Good old Dr. Browne, writing in the middle of the 17th century, spoke of the general scandal of his profession as an excuse for society's refusing him the "honorable style of a Christian"; and Le Sage but reflected the current opinion of his day when he delineated the character of that immortal charlatan, Dr. Sangrado. Or, to come a step nearer to the plumber, think how scandalized the elegant Lord Chesterfield, with his contempt for the mechanic, would have been could he have looked forward but a century and realized the status the engineering profession would attain with the names of Sir Henry Bessemer and a host of others in the nobility of his own dear native land. The changes that have affected the estimate in which certain professions are held are not due to the fickleness of public opinion, but to the advance in the professions themselves. Where in medicine quackery and ignorance ruled, and in mechanics brute force and rule of thumb, we now have the dominion of the natural sciences and the higher mathematics. In short, the education of the men who follow these callings has dignified the callings, and in like manner the education of the plumber in all that pertains to his work is already bringing the coveted reward of honor. Without the education that his work demands, the plumber must remain an ordinary manual laborer; but, with it, he is in a certain sense a sanitary engineer; and that is what he is destined to be, and will be, if he continues the upward course he is now treading.

As at present understood the sanitary engineer is one who serves in an advisory capacity; he plans and perhaps supervises in a general way the sanitation of buildings (we are not here concerned with sewerage); but the actual work of installing fixtures and running pipes is done by the plumber. As a matter of fact, the services of these engineering experts are not in general demand, and the great bulk of the plumbing throughout the country is done under the intelligent and conscientious, or ignorant and conscienceless, direction of the plumber himself. His function is therefore a most important one, and it is not doing violence to truth to say that he holds the health of the community in his hands. The physician merely cures disease; the plumber does, or should, prevent it. Not a day passes that we do not learn anew of the dangers of contaminated drinking water and of air polluted by sewer emanations. Drains must enter either into sewers or cesspools, or, as they might be termed, pest-holes; and, simple as the problem may seem, it is no easy matter to utilize these sewage receivers and at the same time completely insulate them. This is the main problem that the plumber is called upon to solve, and the more clearly he recognizes its difficulties, the more care and thought must be given to its correct solution. Education and skill alone will enable him to direct at will these deadly fluids and gases where they may do no harm, leading them away, without leakage or escape, through their proper channels. It is not necessary to exaggerate the danger of bad plumbing. The plain facts of the case are sufficiently disquieting to all who wish to live and keep in health. Persons have drunk of contaminated water and breathed the air from drains and sewers with no ill effects; but, on the other hand, who cannot recall many instances of sickness and death directly traceable to defective sanitary arrangements?

With the virtual ending of the apprentice system, under which a boy served a number of years in a shop in preparation for a journeyman, the regular training of apprentices disappeared, and a free field was opened to the ignorant and shiftless to pose as qualified journeymen with no better equipment than their own assurance. The conscientious boy could, and did, master his trade by the slow and difficult process of "picking it up" in shops where the master and the journeymen were alike indifferent to his progress; but it is no wonder that the average boy, who is in the majority the world over, shirked along for a few years in one or a dozen different shops, until, having acquired the art of wiping a joint and having perfected himself in profanity and other side lines, he accounted himself a journeyman and as such sought more remunerative employment. The absence of a proper system of training in the trade gave opportunity, furthermore, for foreign work

men to push in to the exclusion of American youths, and then, too, the journeymen, fearing the overcrowding of their ranks, kept out the boys when they could, and too often hindered their education when they could not keep them out.

The late Colonel Auchmuty, whose splendid monument is the New York Trade School, realizing the miserable state of affairs that existed not only in the plumbing, but in the other manual trades as well, devoted the closing years of his life and much of his fortune to bettering the condition of his young countrymen. He saw the younger generation of Americans denied the privilege of learning trades, and resolved to furnish them the opportunity for education that the old apprenticeship system had afforded. In an address on "Trade Training" delivered before the National Association of Builders in 1889, Colonel Auchmuty said: "If then the master mechanic is no longer able to give much personal attention to his apprentice, because his time can be more profitably spent in his office than in his workshop, and, if the workshop, owing to the subdivision of labor, is no longer the best place to learn a trade, some other system of training the young mechanic must be found. That system would seem to be afforded by the trade school, where trades are taught precisely as the professions are now taught in professional schools."

Led by the New York Trade School, other schools and classes have come into being, until now there are several places where the "art and mystery" of plumbing may be conquered. It is in the east that the greatest progress has thus far been made, but whenever the west awakes to the need of this line of manual education, the liberality and magnificent enterprise of that region will, without doubt, find plentiful expression. Foreign labor has not yet encroached upon the right of the native there as it has in the older cities of the Atlantic seaboard, and, furthermore, a new country is less particular as to the quality of its domestic engineering; a Kansas farmer has not the same sanitary ideals as the Fifth avenue householder.

The New York Trade School has already been mentioned. Besides its plumbing class, which has been the most popular in point of members, the attendance during 1893 in the day and evening classes being 287 out of a total attendance at the school of 556, it has classes in bricklaying, plastering, carpentry, house painting, stone cutting, fresco painting, blacksmithing, sign painting, printing, steam and hot water fitting, tinsmithing, and roofing and cornice work. In the Department of Science and Technology of the Pratt Institute, Brooklyn, N. Y., there is a two years' course in plumbing, at the end of which an examination is held by a committee of the Journeymen Plumbers' Association of Brooklyn and certificates awarded. Should the holder af-

terwards apply for admission to the association, this certificate is accepted in place of the examination of like character otherwise required.

The Master Builders' Mechanical Trade School of Philadelphia, while instituted primarily for evening instruction in the building trades, such as carpentry, bricklaying, etc., has with the most satisfactory results given attention to plumbing, there being a nine months' course of three evenings per week, during which both manual and theoretical instruction are given to the students.

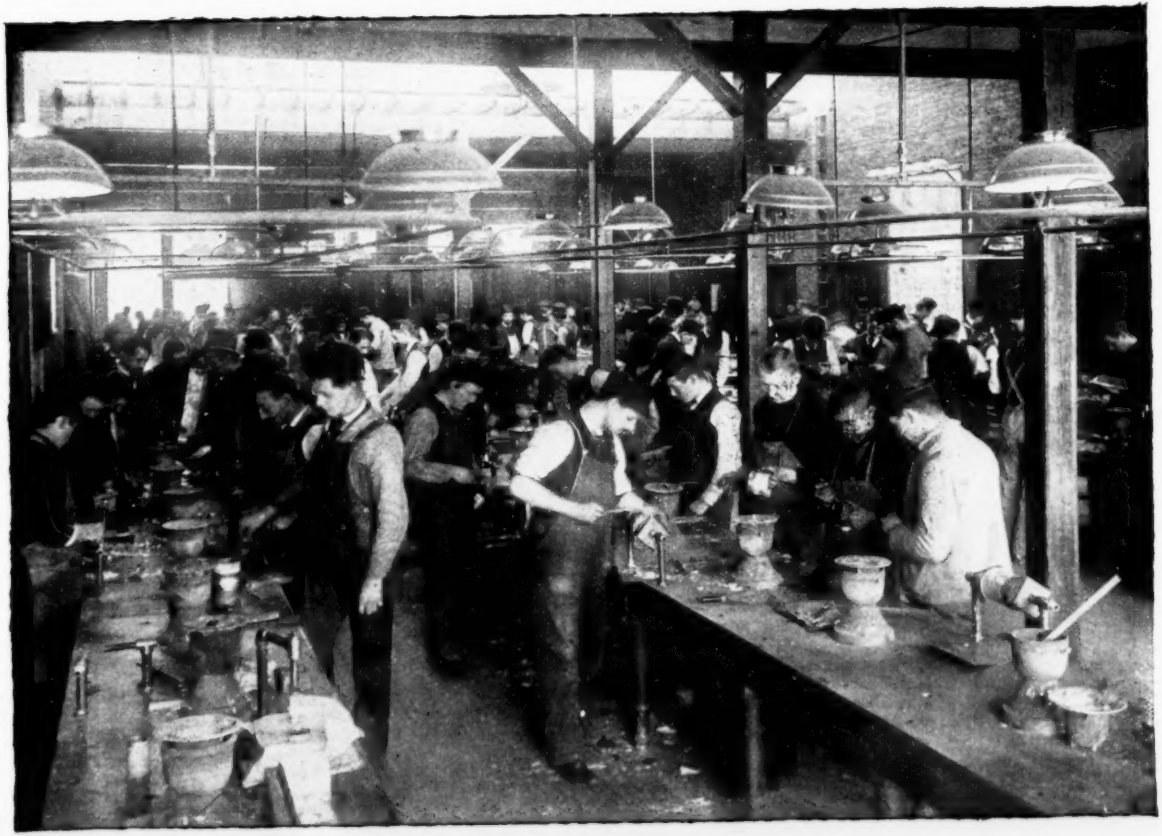
The three schools just mentioned are the best known places for instruction of this kind, and each is proving by its work to be of incalculable benefit to a host of ambitious young craftsmen. It should be borne in mind that these institutions are not of the eleemosynary sort, where juvenile unfortunates are taught and cared for without cost to themselves, but rather they are schools where the self-respecting young mechanic can, at a reasonable expense, attain the instruction he is searching for. Other classes there are in New York and elsewhere for instruction in plumbing, like that in the Springfield (Mass.) Christian Industrial and Technical School, the Baron de Hirsch Trade School for indigent Hebrews, and the North End Union of Boston, where the pupils are afforded the means to rise from poverty and industrial helplessness by their own efforts; and in this connection, though not of this kind, mention at least by name should be made of the trade school of the Elmira State Reformatory, where plumbing is a popular and successful course.

To give anything like a full account of the methods of instruction pursued at the New York Trade School, the Pratt Institute, and the Philadelphia Master Builders' School, with comparisons between the merits of the systems as they vary in these schools, is clearly unnecessary here. It will suffice to merely outline the course of instruction inaugurated by Col. Auchmuty at the first-mentioned institution. The course of plumbing at the New York Trade School includes day and evening classes; in the former, for which the charge is $40, instruction is given every day in the week for a period of four months; and in the latter, for which the fees are $14, three evenings in the week for a period of five and a half months. The day class is reserved for young men between 18 and 22 years of age, and the hours of work are from 8 o'clock in the morning till 4 o'clock in the afternoon, stopping at 2.30 P. M. on Saturdays. At present the class is limited to 120 scholars, but so popular is the course that last year a number of applicants had to be refused because of lack of accommodation. The evening class for young men between 16 and 21 years of age is divided into two sections of 75 each, who are taught on alternate evenings from 7 till 9.30 o'clock; and on Friday evenings both sec-

tions are instructed by lectures in the theoretical features of the work. The manual instruction is given in a shop specially designed and fitted up for the purpose, where the scholars, under competent instructors, are carried along from the simplest work in the manipulation of lead and solder through all the different stages of "joint wiping" up to pipe bending, fixture setting, boiler work, etc. There is also a special course in lead burning for the day class, for which extra charge is made.

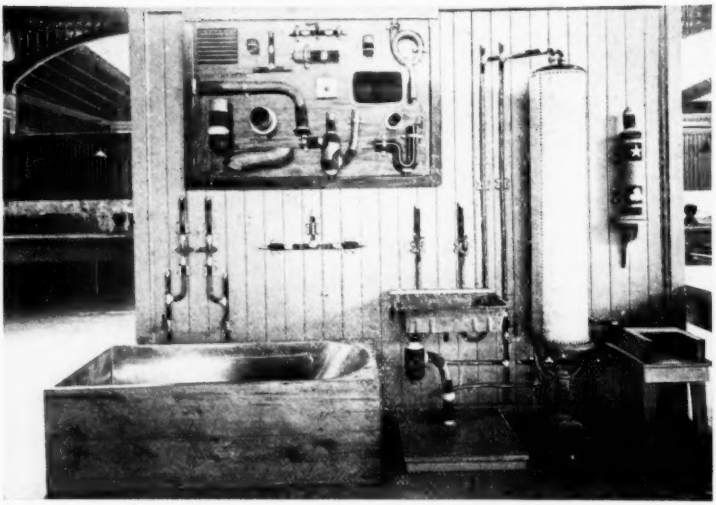
The most important and difficult step in the mastery of the plumber's art is learning to wipe a joint. It is as near the one thing needful to competency in this particular calling as any single operation can be. Briefly told, it is the joining of two pieces of lead pipe by means of an elongated bulb of solder. The melted solder is poured on the abutting ends of the pipe and dexterously caught on a cloth pad: it is then delicately manipulated over and under and around the joint as it stiffens in cooling until it finally hardens into a silvery bulb of symmetrical proportions. The operation, which is so easy in telling, means hours and days of patient labor, burns innumerable, and failure upon failure,—altogether such a self-disciplining task as would have been joyfully imposed upon the youth by the law-givers of old Sparta. But this feat in lead working must be mastered, and mastered too in all its applications. Its importance will be appreciated from the statement that of the sixteen operations that constitute the regular course of manual instruction eleven are concerned with "wiping." The scholar must learn to wipe a horizontal round joint, horizontal branch joint, upright round joint, ¼ bend, upright branch joint, stop cock, flange, ferrule, bath plug, vertical branch, and side flange. The tasks are appointed in the order of increasing difficulty, and the young men are kept at each operation until they become proficient in it and can turn out a workmanlike job. The instructors inspect the work and give what assistance they can, but, from the nature of the case, the process of manipulating the metal successfully can only be acquired by careful and continued effort. The dexterous scholar will quickly pick up the art of handling molten metal, and is advanced accordingly; but the clumsy novice, with no deftness of touch, finds it an all but impossible task, and the course is often ended before he has solved the entire number of material problems that are set for him to do.

For the scientific instruction, question blanks are furnished and the lecturer takes the questions in order, writing the answers on a blackboard from which the scholars copy them into their blanks. Along with the answers, the lecturer fully explains the subject with the aid of diagrams, and this plan of imparting information has been found extremely efficient. The lecture course covers water supply and drain-



THE PLUMBING CLASS AT WORK, NEW YORK TRADE SCHOOL.

HOME OF THE NEW YORK TRADE SCHOOL.



SAMPLE OF WORK AT THE PRATT INSTITUTE, BROOKLYN.

age as applied to house plumbing, some of the principal subjects being: service and waste pipes, trapping, ventilation, boilers, tanks, fixtures, and pumps. In addition to the regular instruction, the day students are taught bookkeeping and mechanical drawing, and are taken to the showrooms of dealers in plumbers' supplies to inspect the latest appliances and fixtures; they are likewise required to fill out specifications to conform to the rules of the New York Board of Health. At

the expiration of the course the scholars are examined by a committee of the New York Master Plumbers' Association, and certificates are given to those entitled to them.

The opportunity to learn their trade more rapidly that the evening class offers to boys who work all day in plumbing shops, is very generally appreciated, as is proved by the fact that the great majority of students are "helpers" who thus reduce their term of service by a year and, at the same time, acquire a better grounding in the principles of their trade. On the other hand, the day class is mainly composed of young men who have no previous knowledge of this trade, but are able to give their entire time to learning it.

From this necessarily brief account of the plumbing class at the New York Trade School, it will be profitable to consider for a moment the present scope of the plumbing school and the advantages it affords. In a recent letter Mr. W. A. H. Allen, the efficient superintendent of the Master Builders' Mechanical Trade School of Philadelphia, writes as follows:

> It has been shown that evening instruction can give such knowledge that an employer will have no inducement to employ his apprentices in errand boy's work, and, to go further, some graduates, already apprentices, have stated that the information obtained in one term exceeded that of a year in the shop. In a trade like plumbing the apprentice must, of course, be occupied with whatever class of work comes to the shop, and it has happened that some of two years' standing had experience only in gas and steam fitting. Naturally, they were anxious to learn something of lead working before completing their time, and in the trade school found the opportunity they desired. . . . In the trades the great trouble is that workmen learn from each other the mechanical execution of a certain process with no knowledge of any principle to guide them if the conditions are changed. Unfortunately, also, they rather distrust books, and have no faith in science as applied to mechanical work. How many are acquainted with a general rule for obtaining the capacity of a tank of any of the usual shapes, can determine the size of a tank which will contain a given quantity of water, or find the size of several outlets of different diameter which will aggregate the area of the main? Tables are convenient, but he who knows only one way of performing a certain calculation will surely find himself often at a loss how to proceed. To many, a drawing conveys no more idea than a written page to him who cannot read, and, though they know that in the course of time they will be called on to interpret a plan, yet they usually leave such knowledge to come to them by intuition. But they appreciate its value. and applications have been received from journeymen for that part of the course reserved for the evenings devoted to theoretical instruction.

It will be seen that the function of the trade school is not alone to give manual instruction in the different processes of work, but also to instill a knowledge of principles, so that the scholar may be capable of mastering his trade in all its ramifications. A single scientific principle thoroughly comprehended will bring solutions to a hundred specific problems. For example, the hydrostatic law that the pressure of water is due to its depth independent of the size or shape of the containing

vessel is of constant application in plumbing, and it is surprising how persistently the untaught mind questions this fundamental fact. That a column of water an inch in diameter will balance one of equal height twenty feet in diameter, and that a half-dozen branch pipes leading to a single closed reservoir below give no more pressure than one pipe would give, is an unceasing puzzle to the ignorant, and the plumbing papers in their correspondence departments are continually called upon to answer this question in one or another of the myriad forms in which it is propounded. That a suction pump cannot possibly lift over 34 feet is another question of similar difficulty, and the list of such questions might be indefinitely extended. Now an able lecturer, in half an hour's talk, with the help of illustrations, can so impress upon the scholars the principles governing these cases that, however the question may arise in after practical experience, it will never occasion the slightest doubt in mind or hesitancy in action.

Another thing to bear in mind in connection with the theoretical instruction the trade schools afford is that manual dexterity in the working of lead will be of less account in the future than it has been in the past. Much high-class plumbing nowadays involves no lead work at all, and the use of iron and brass pipe, together with the extensive variety of fixtures and fittings on the market, relieves the plumber of a great deal of special labor peculiar to his trade. So far, therefore, as the manual work is concerned, he will tend to become merely a good general mechanic, but well-versed in sanitary science ; and more and more emphasis will be laid upon the latter qualification.

That the plumbing trade schools, as at present conducted, do not fulfill to the letter all that was prophesied of them will hardly be denied, but that they do fulfill in a large measure the promise of their beginning is a fact beyond dispute. Apart from all outside influences, such as the opposition of trade unions that wish to keep down the number of skilled mechanics in their calling, there are other difficulties in the way of perfect success. The course in the trade school is necessarily short, and also, from the nature of the case, much of the scholar's labor is expended upon mere school exercises ; and such work, in spite of all that may be said to the contrary, does not appeal to the scholar and stimulate him in the way that work to some directly practical end, for which he will be paid, appeals and stimulates. He will perhaps master the principles of his work more thoroughly in the school than in the shop, but the finished school exercise shows the touch of the amateur more evidently than the corresponding operation performed under the less friendly eye of a wage-paying employer.

Then, too, the large number of young men in the classes prevents the continual supervision of the instructor, and he cannot, therefore,

THE PLUMBING CLASS AT WORK, MECHANICAL TRADE SCHOOLS, PHILADELPHIA.

correct each misapplied effort and faulty manipulation. Finally, the young men themselves, though far more conscientious than a similar number of students in any college, will, at times, with the nonchalance of youth, evade their duty, and even the fact that they are paying for the instruction with their own hard earned dollars, or out of the scanty savings of a parent, will not altogether overcome the careless spirit of indolence. To find a class of scholars, even in a trade school, devoted to their work without cessation, and free from every trace of desire to shirk, would be to find, not a class of flesh and blood young men, but a company of apprentice angels who had strayed away from heaven. But it is a thankless task to point out the practical deficiencies of schemes of instruction offered by the trade schools. These institutions are all doing a noble work, and the increasing number of better educated mechanics that they are yearly sending forth will do much to advance the status of the plumbing and other manual trades.

PRACTICAL LABORATORY TRAINING FOR METALLURGISTS.

By Professor Robert H. Richards.

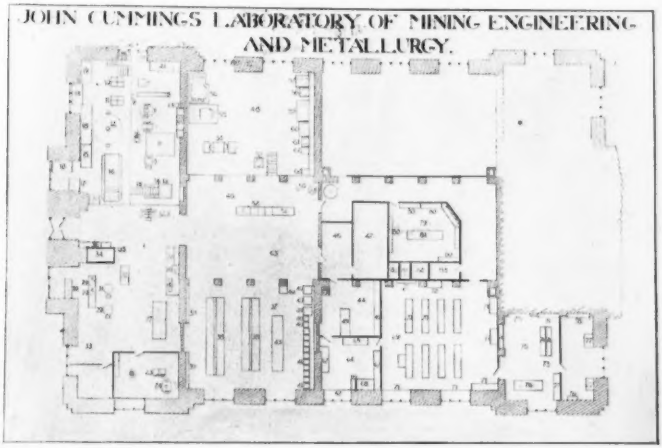
THE marked change in methods in education during the past thirty years is nowhere more plainly seen than in the light in which laboratory instruction of any kind is regarded.

If the question had been asked in 1865, "Is it necessary to have laboratories of ore-dressing and metallurgy in a school of mining engineering and metallurgy?" it would have been necessary to defend with all the arguments that could be produced the position that teaching by experience from contact with things was a powerful step forward in education.

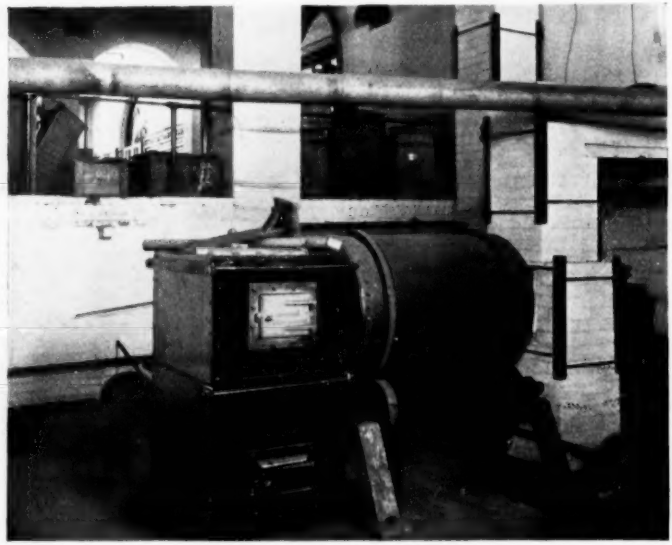
Now, however, the development of the modern experimental method of teaching has been carried so far and with such success that defense is unnecessary. In the grammar and high schools manual training and drawing give a reality to arithmetic, algebra, and geometry. In chemistry and physics experimental laboratories clear up the meaning of the text-books. In literature, language, history, and mathematics the use of charts and diagrams makes clear the meaning of the books. In civil, mechanical, and electrical engineering field practice, machine work, testing power, economy, and efficiency, together with drawing, round out the text-book work with the experience necessary for a full understanding of it. To go farther, some of the strongest schools of mining and metallurgy in the country have become so largely through the development of field work and summer schools and of laboratories of mining and metallurgy.

In comparing the three great engineering professions, civil, mechanical, and mining engineering, it will be seen that the civil engineer deals with bridges, roofs, dams, aqueducts, and reservoirs: all of which are fixed structures and mostly with fixed load. The conditions are disturbed by trains, heavy snows and winds, floods, frosts, and thaws to a certain extent, but it does not appear difficult to obtain a factor of safety which will ensure protection from accident. This factor of safety is comparatively small. The mechanical engineer deals with machines which, besides the statical forces, have to resist inertia, momentum, and impact. Here the range of possibilities is much greater; hence the factor of safety has to be much larger than with the structures of the civil engineer. The mining engineer, on the other hand, has to deal with the uncertainty of the mine roofs, mine water, and, in

ROGERS BUILDING, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, METALLURGICAL LABORATORY IN BASEMENT.



1. Milling Room.
2. Blake Crusher.
3. Cornish Rolls.
4. Gates Crusher.
5. Sample Grinder.
6. Iron Sampling-Floor.
7. Cornish Automatic Feeder.
8. Trough Automatic Feeder.
9. Spitz Lutte.
10. Coarse Collom Jig.
11. Fine Collom Jig.
12. Slime Table.
13. Hendy Feeder.
14. California Stamps.
15. Amalgamated Plates.
16. Frue Vanner.
17. Jig with Moving Sieve.
18. Water Tanks.
19. Steam Drying Tables.
20. Sample Bucking Plates, etc.
21. Sampling Table.
22. Ore Bins.
23. Pounding Block.
24. Upright Engine.
25. Dynamo 50V x 50A.
26. Dynamo 2V x 50A.
27. Depositing Table.
28. Leaching Tubs.
29. Larger Amalgamating Pans.
30. Smaller Amalgamating Pans.
31. Settler.
32. Tank.
33. Space to grow in.
34. Store Room.
35. Blacksmith's Drilling Machine.
36.1. Carpenter's Bench.
36.2. Double Ball Grinding Mill.
37. Assaying Room.
38. Students' Desks.
39. Ore Balances.
40. Muffle Furnaces.
41. Crucible Furnaces.
42. Great Stack.
43. Iron Table.
44. Balance Room.
45. Fine Balances.
46. Store Room.
47. Store Room.
48. Furnace Room.
49. Blacksmith Forge.
50. Anvil.
51. Blacksmith Table.
52. Water Jacket Furnace.
53. Furnace Ore Bins.
54. Brückner Roasting Cylinder.
55. Copper Refining Furnace.
56. Larger Calcinining Reverberatory.
57. Roasting Kiln.
58. Lead Kettle.
59. Larger Cupelling Furnace.
60. Smaller Calcining Reverberatory.
61. Smaller Cupelling Furnace.
62. Pot Furnaces.
63. Space to grow.
64. Professors' Laboratory.
65. Table for Electrolytic Work.
66. Experimental Spitzlutte.
67. Chemical Desks.
68. Hood.
69. Blowpipe Room.
70. Tables.
71. Cases for Apparatus, etc.
72. Sink.
73. Library.
74. Bookcase.
75. Space to grow.
76. Table.
77. Professors' Desks.
78. Lithographic Notes, etc.
79. Toilet Room.
80. Lockers.
81. Basins.
82. Closets.
83. Professors' Room.



BRUCKNER ROASTING FURNACE.

fact, the very life of the mine—all of which call for the development of judgment to a marked degree. Metaphorically speaking, we may say that his formula is mostly factor of safety, and that the factor of safety is determined by his judgment.

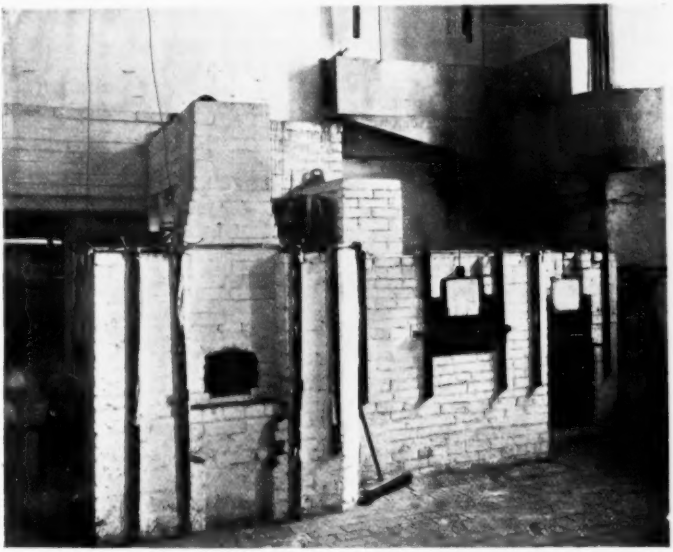
How much more important does it seem, then, that the young mining engineer and metallurgist should early begin to learn by experience from actual professional work, not only in order that he may gain the advantage of interpreting his text-books intelligently, but also to store up that fund of experience upon which his active professional work must so largely depend.

A school of mining and metallurgy, then, needs a laboratory for ore-dressing and one for smelting and other reduction processes to give the young engineer a good start in acquiring from his own personal experience the principles involved in his profession. He can make this beginning much better with guidance than without it. Hence it is better for him to become accustomed to machines and processes in the school than after he leaves it. Again, experience acquired during the school course reacts upon the lectures, which, as a result, immediately cease to be abstract dissertations and become concrete acquisitions.

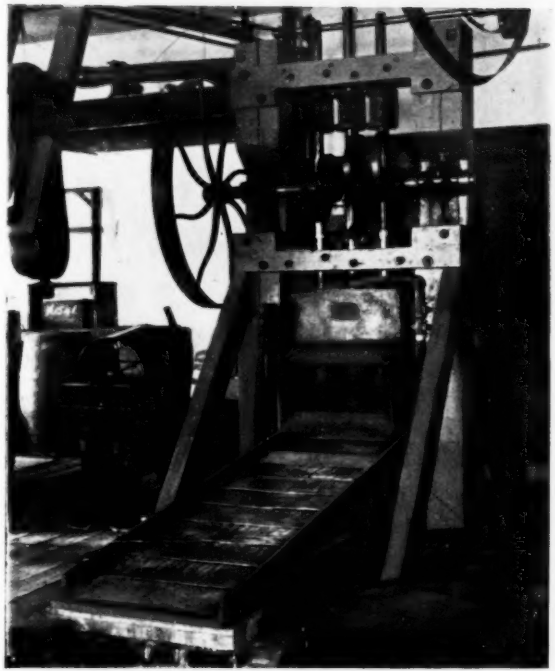
The laboratory should contain apparatus which it is practicable to

use for treatment of ores. The ore-dressing, roasting, amalgamation, lixiviation, smelting, and refining of the ores of gold, silver, copper, and lead furnish the desired field. Mining operations are impracticable: prospecting, sinking, drifting, stoping, hoisting, can only be taken as field work; they can none of them be adapted for school laboratory work. The metallurgy of iron and steel, including smelting, puddling, Bessemerizing, open-hearth and crucible steel, has not been adopted, owing to the magnitude of the quantity of material and the time, labor, and cost incurred. It is not probable that any of them will be adopted in the school, unless possibly the last mentioned. In fact, they are not needed, as the young man can study the principles of metallurgy just as well with the copper, lead, silver, and gold ores. But the fact that it is only principles which are being taught in the laboratory, and not practical details, cannot be too strongly emphasized. It is true that principles are well taught by the use of correct practice. But practice is an incident only, and one on which the student cannot afford to spend his school time.

A strong point in favor of laboratory training is the opportunity that is afforded to learn by making mistakes. For example, if a student in roasting a gold ore preparatory to gas chlorination fails to

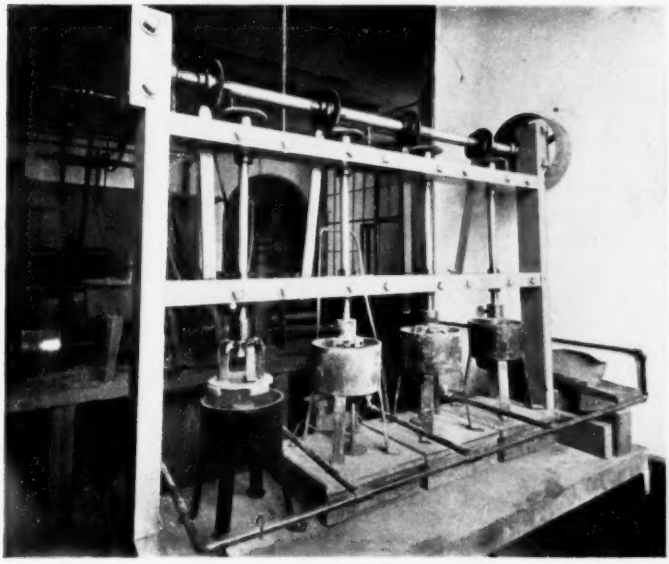


COPPER REFINING FURNACE AND ROASTING FURNACE.



STAMP BATTERY AND AMALGAMATED PLATES.

LEACHING TUBS ARRANGED FOR MECHANICAL STIRRING.



SET OF SMALL AMALGAMATING PANS.

read his instructions and puts salt in with the ore at the beginning of the roasting, he may find, when he takes account of stock, that from twenty to forty per cent. of his gold has disappeared up the chimney. The results of the test are:

a. A loss of gold amounting to $1.00 or less.

b. The student has learned that gold chloride is volatile.

c. The student has learned that, if he would succeed at anything, he must get all the known facts about it before beginning the test.

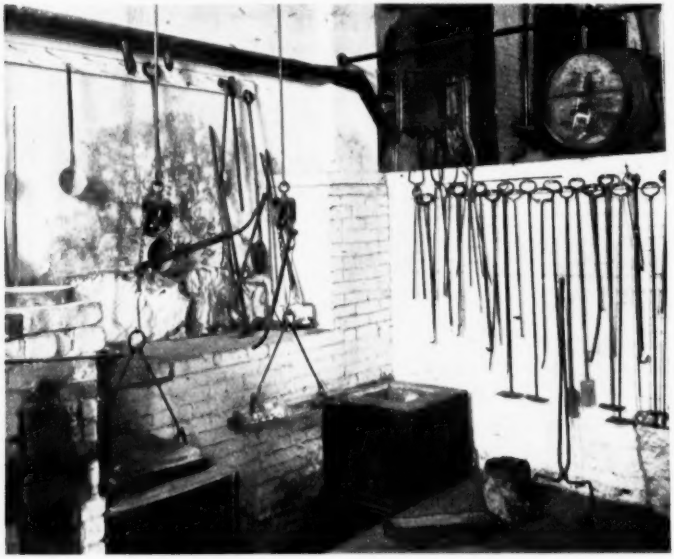
Which of these three results is of greatest value to the student?

Undoubtedly the last is by far the greatest, because it reaches into all metallurgy, while the first two are but isolated facts. But one may say, "The latter is not metallurgy at all; it is common sense." The reply is that we must make the man before we can make the metallurgist. We must cultivate common sense in metallurgy by every possible means, and that is the object of the laboratory.

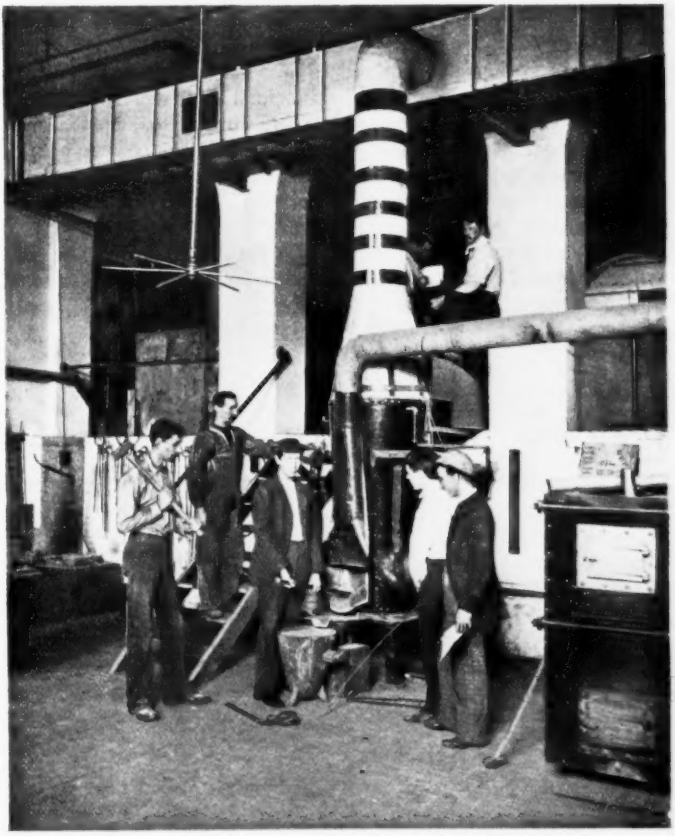
It has sometimes been urged that a laboratory of this sort ought to settle many important metallurgical questions: for example, what is the best rate of fall and height of discharge of stamps for the maximum amount crushed for the power employed? It should be able to settle such vexed metallurgical questions, but this goal will not be reached

largely with undergraduate work. The moment the experiments are so guarded that the student cannot make his mistakes and gain his experience, the advantage of the laboratory to him is largely curtailed. The mode in which advanced metallurgical experiments can be obtained is through the return to the school of older, more mature men who come to the laboratory with the sole purpose of working out some problem. To these the laboratory should always be open, and their work should prove of the highest value to the metallurgical world.

In order that a process may be suitable for adoption in a mining and metallurgical laboratory, it must teach some ore-dressing or metallurgical facts and give some experience. The student must have an opportunity to exercise his judgment; first in selecting his process, then in operating the process chosen. Therefore, it is well that there be alternative processes. An illustration may be taken from work with a slime table. The questions arise: shall clean heads be made and the tails be treated again; or, shall there be clean tails and the heads be treated over; or, shall there be clean heads and tails with a middling product? These same questions again arise in regard to smelting for the greatest quantity of clean metal and clean slag: shall the lead be held in the crucible of the furnace and tapped



FURNACES FOR POT MELTING, WITH TRAVELING LIFT FOR COVERS.



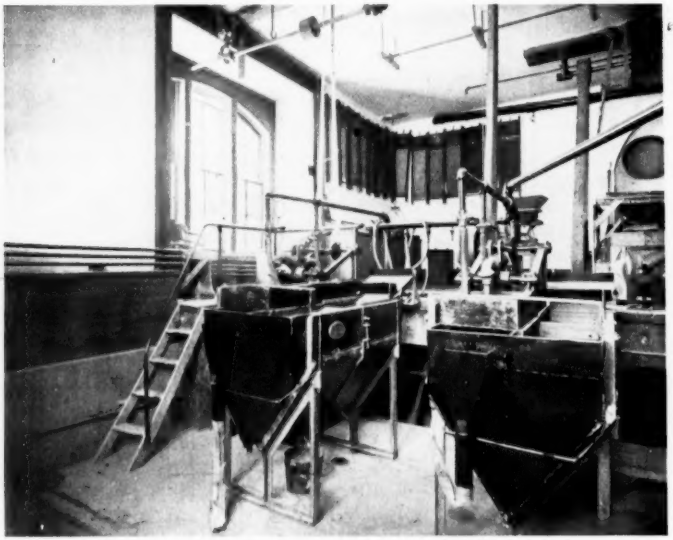
WATER-JACKET FURNACE FOR SMELTING LEAD AND COPPER ORES.

out periodically; shall a lead well be used; shall a fore hearth be used; or shall the lead, matte, and slag be tapped out clean and all together at every tap?

Finally the student should have means to test his results in order that he not only may see if his selection of the process was good, but also may form his conclusions in regard to operating the process. If smelting is to be done, the student should analyze his materials, calculate his charge, make his smelt, and analyze his slag, in order that he may ascertain how nearly his results agree with the plan he made. He should then take a complete account of stock, and account in each case for

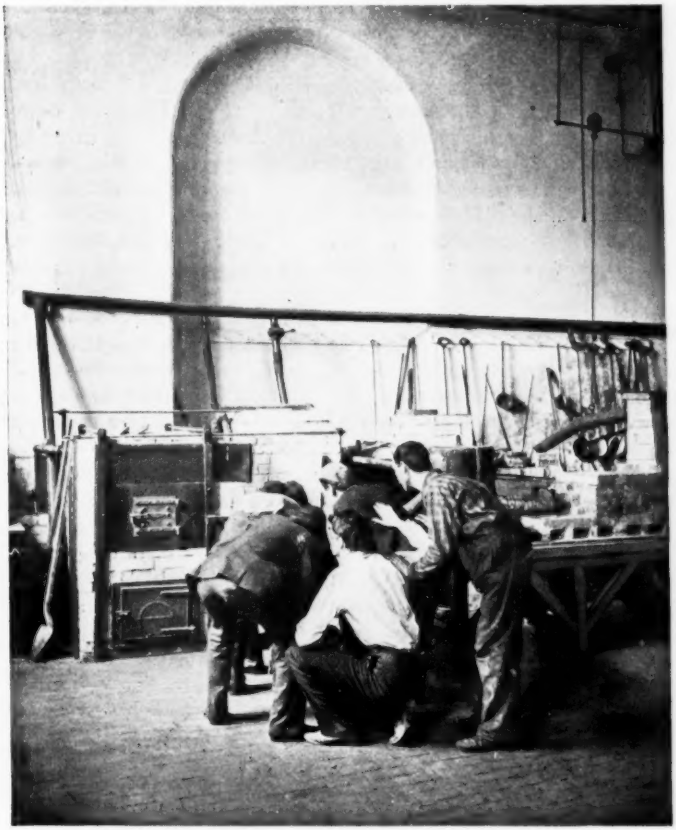
every bit of the valuable metal lost. This careful account of stock is one of the most valuable parts of the student's training. He sees how much depends upon slight variation in process and upon the careful handling of material when upon the sum total of these items rests the difference between profit and loss. Where work is done upon a small scale,—for example, as in amalgamation,—the student may try a series of experiments in search for the conditions yielding the highest rate of extraction. Wherever possible, highest net economy or highest extraction should be brought into the work.

The scale upon which laboratory work should be done will be governed by several considerations. It must be large enough to give some



A PAIR OF 2-SIEVE COLLOM JIGS.

real experience approaching practice with both the physical and chemical forces at issue, but not so large as to tire out and discourage the student by the sheer effort of the mechanical handling of the ore and products. Other considerations—such as the distance from the mines and the cost of purchasing and freighting the ore (in case it is not given in return for results)—will tend toward a solution of the question of the amount to be handled. This will also determine the size of the apparatus to be selected. An instance will perhaps best show the manner of deciding this point. A California gold stamp battery will crush



CUPELLING FURNACE—STUDENTS WATCHING FOR THE "BLICK."

from ten to fifteen tons in twenty-four hours with an average of perhaps twelve tons. It would then crush one thousand pounds of gold quartz in one hour. If, for reasons previously given, one thousand pounds of gold ore was the quantity found to be the most desirable for treatment, then the full-sized battery would stamp it so quickly that there would be very little experience gained by the use of it. A far better proportion would be 250-pound stamps and three of them in the one battery. Such a set of stamps would take seven to eight hours to crush the one thousand pounds of gold ore, and would give a day of good experience to the student in charge, as well as to

the members of his class. In like manner the size of all the machines should be selected with reference to their speed of treatment and the quantity to be treated.

The student's work will naturally divide itself into (*a*) the period of preparation, (*b*) the period of experimenting, and (*c*) that of cleaning up and taking account of stock. Each member of a class may be assigned his own complete metallurgical process. During the first and last periods above mentioned he will naturally work alone and without the help of his classmates. But when the ore treatment is to be done, then the whole class will be called in to render assistance. In this way all will gain experience from working the machines or furnaces.

Another advantage which the student derives from his laboratory work is the ease with which he can go from the laboratory into the smelting works or mills. The transition is made without any great plunge. He has, as it were, been there already. This saves his self-respect with the men, and brings him into a condition much nearer to usefulness at the start than any attainable by other known systems.

The director of a laboratory must have both the knowledge and the skill to do all the kinds of work in the curriculum, and he must have had experience enough in metallurgy to help the student to reach wise decisions as to his methods and just conclusions as to his results, that he may get the most out of his work, and avoid going off on too many fool's errands. The director must make the interest of his students his first care, and not allow the advancement of science or of business interests to interfere in any way with the highest development of the student.

The laboratory must be considered simply as a means to an end, and that end is the development of the student's power to investigate and to execute.

[The illustrations accompanying Professor Richards' article show the building containing the metallurgical laboratory of the Massachusetts Institute of Technology, the apportionment of space, and the more important items of the plant.—EDITOR.]

OPERATING MACHINE TOOLS BY ELECTRICITY.

By George Richmond.

THE principal office of the machine tool being to remove surplus metal, it would seem that a direct relation might be established between the weight of cuttings produced and the work done by the driving engine. Experiments on a variety of tools have shown that 1 horse-power applied directly is sufficient to remove about 40 pounds of cast iron, 33 pounds of wrought iron, and 23 pounds of steel.

Any attempt to utilize these results in estimating the power of the engine would require the introduction of an efficiency factor, so small and variable in amount as to reduce the operation to that of a mere guess.

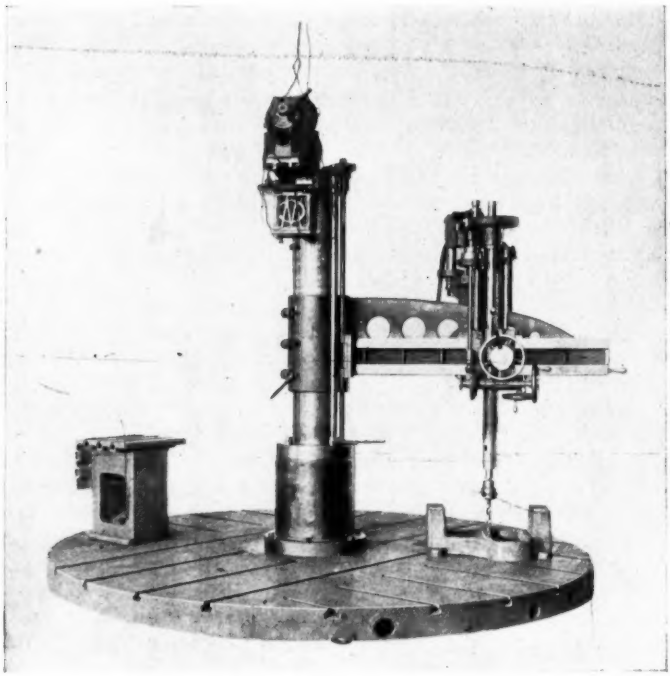
It is well, indeed, to keep this ultimate ratio in mind, for the additional work expended is that alone which is capable of reduction, and it is so enormous in amount as to leave room for the exercise of judgment in various directions. Something may be effected by the discretion of the foreman in choosing the proper tool for doing the work, and by the workman in keeping his tools in proper condition for cutting off the maximum amount with a given power, and still more in keeping the machine in easy running order; but there remains a large amount of work expended by the engine which is unaccounted for, either by the heap of cuttings or the friction of the tool itself.

The following table* gives some actual data on this subject, from which we see that the lost work varies from 15 to 80 per cent., giving an average in the ten shops of 38.6 per cent. It is extremely difficult to make these comparisons in such a manner as to draw fair conclusions, for in the first place it is obvious that the larger the extent of the establishment and the greater the area over which the power is distributed, the larger will be the proportion of lost work. The engine is rarely, if ever, located with a view to driving the whole of the machinery with which it is ultimately connected to the best advantage as regards transmission. Such a position would theoretically be found by a process similar to that of finding the center of gravity, so that the engine might transmit the same power in every direction. As it is, the addition of extra machinery at a point necessarily very remote from the engine may involve not only the work required to drive it,

*From Dynamometers and Measurement of Power. Prof. J. J. Flather.

HORSE POWER.

Name of Firm.	Nature of Work.	Total.	To drive Shafting.	Per cent. to drive Shafting.
J. A. Fay & Co.	Wood-working machinery.	100	15	.15
Union Iron Works	Engines, mining machinery	400	95	.23
Frontier Iron & Brass Works.	Marine engines, etc.	25	8	.32
Baldwin Locomotive Works.	Locomotives.	2500	2000	.80
W. Sellers & Co. (one dep't.)	Heavy machinery.	102.45	40.89	.40
Pond Machine Tool Co.	Machine-tools.	180	75	.41
Yale & Towne Co.	Cranes and locks.	135.05	66.81	.49
Ferracute Machine Co.	Presses and dies.	35	11	.31
Bridgeport Forge Co.	Heavy forgings.	150	75	.50
Hartford Machine Screw Co.	Machine screws.	400	300	.25

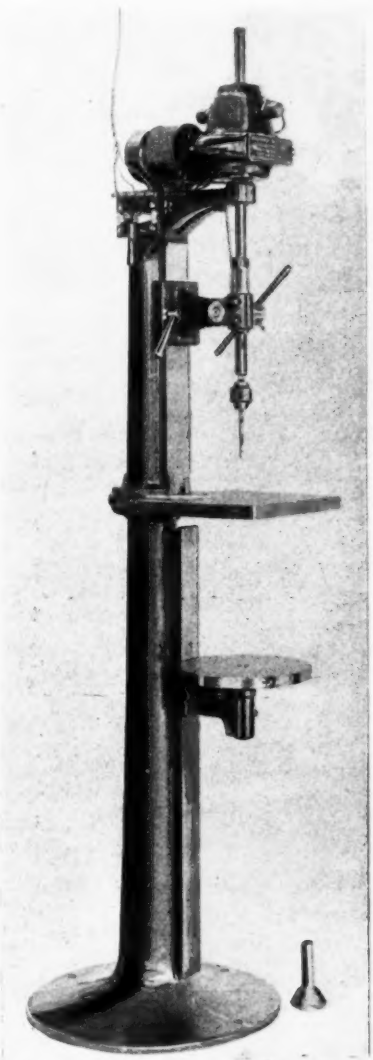


A CROCKER-WHEELER MOTOR OPERATING A RADIAL DRILL PRESS.

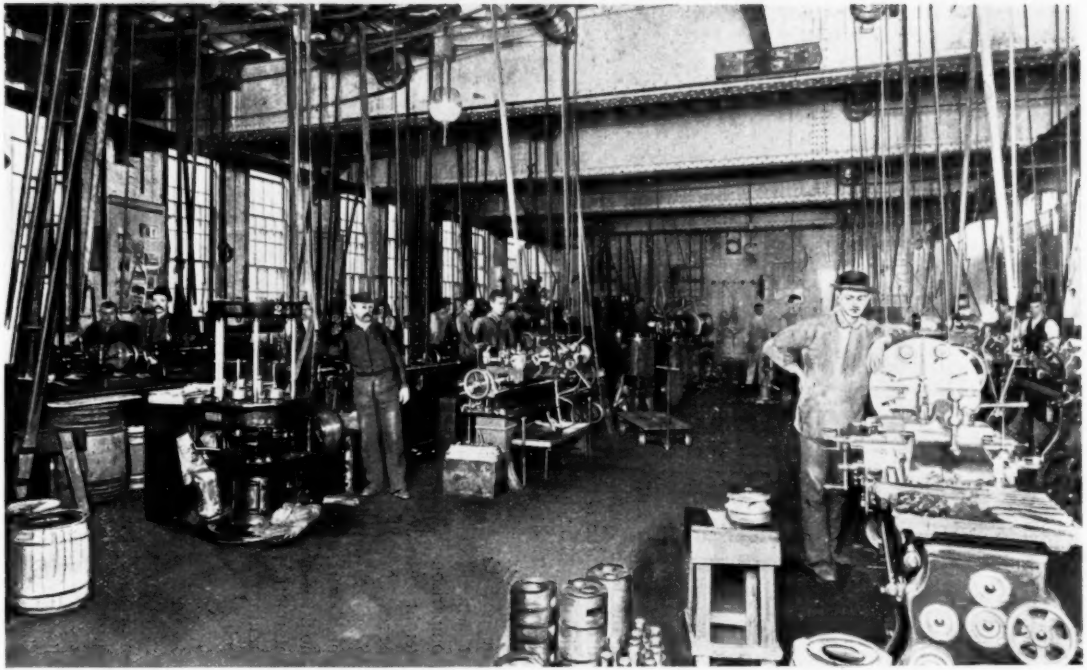
but a strengthening of the main shafting and consequently additional friction along the whole line of transmission. Moreover, the relative continuity of running is a factor which must be taken into account, for the lost work expended in transmission is the same whether the tool is run one hour or ten.

The cure for this, proposed by the electrical engineer, is, in its most radical form, to attach a motor to each machine-tool. In even the largest and most straggling establishments the cost in the leads for transmission to the machine is then insignificant. The power consumed is strictly proportional to the work done, and we are now brought to a point at which we can make a comparison between the weight of the cuttings and the reading of the Watt meter. We should not indeed get a very constant ratio, but we should obtain some valuable information as to the efficient running of the machine as such, and the man handling it. A less radical solution is to group a number of machines around a motor admitting of an infinite variety of combinations,—from that of two or three machines to that of all those on the same floor or in the same shop.

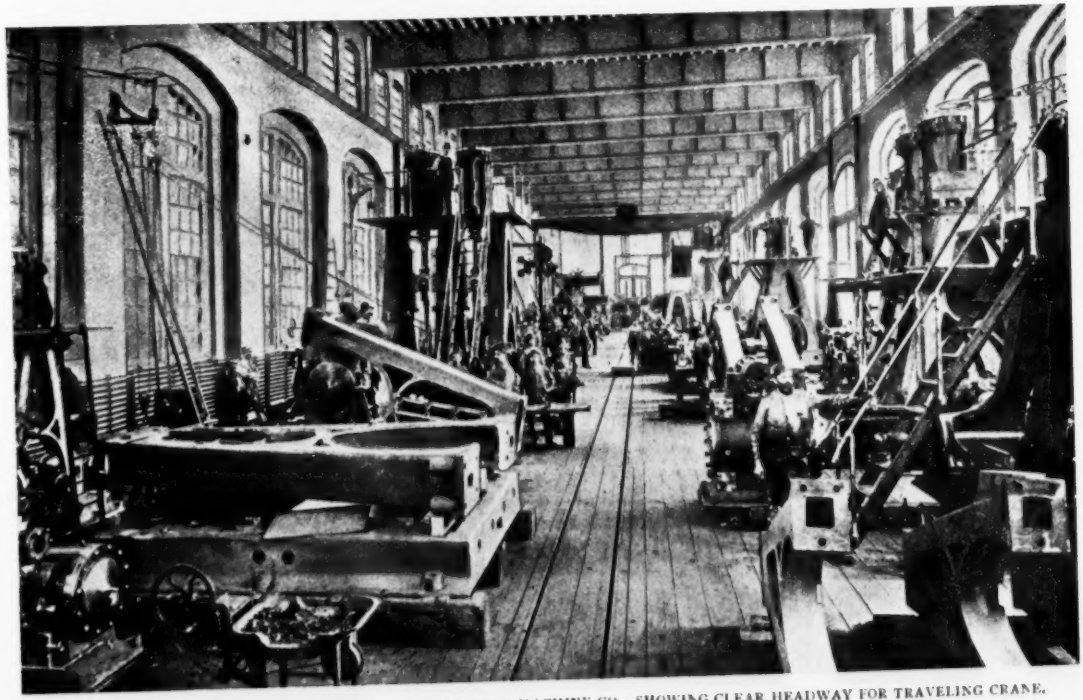
The first solution is that



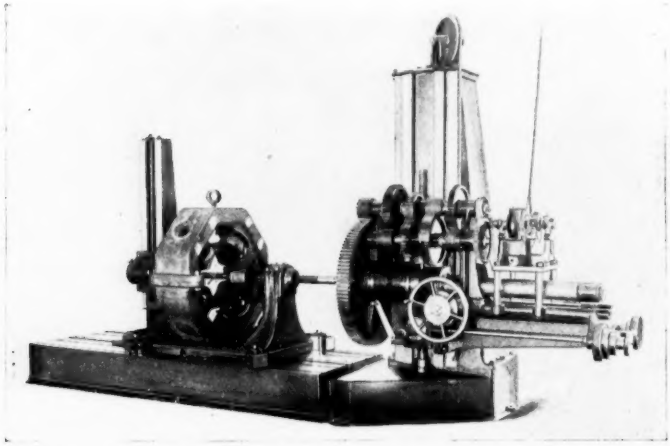
VARIABLE SPEED ELECTRIC DRILL PRESS.



INTERIOR OF MACHINE SHOP, SHOWING MAZE OF BELTS AND COUNTER-SHAFTING AVOIDED IN ELECTRIC DRIVING.

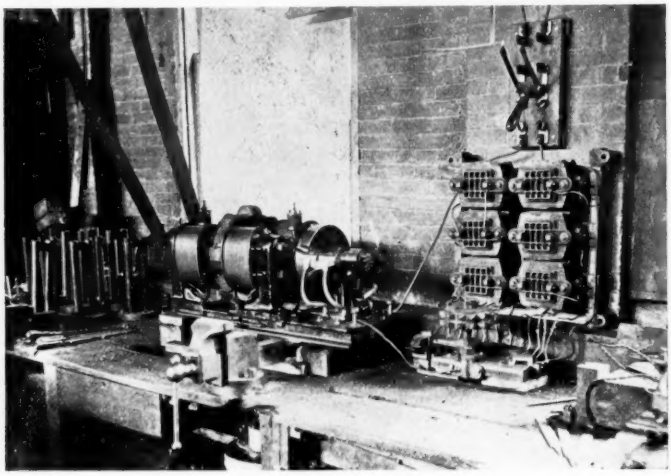


ERECTING DEPARTMENT, DE LA VERGNE REFRIGERATING MACHINE CO., SHOWING CLEAR HEADWAY FOR TRAVELING CRANE.

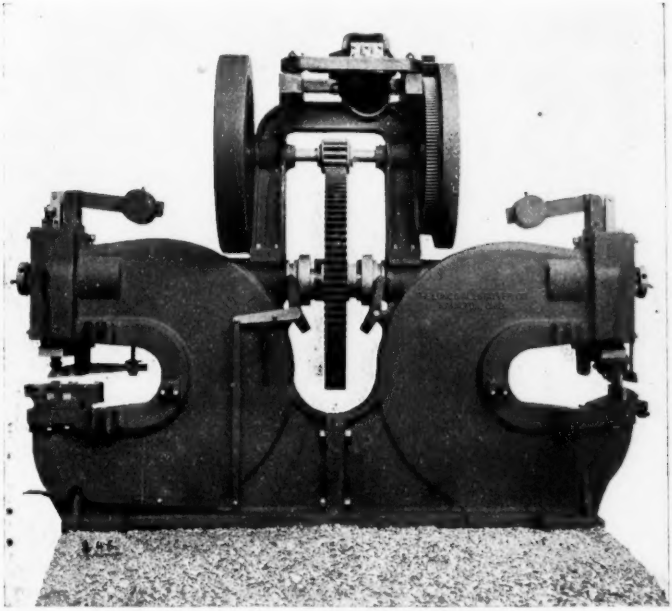


10-TON BORING MILL, CHANGE GEARING; POWER SUPPLIED THROUGH LAMP CORD TO 1 H. P. MOTOR ON BORING HEAD.

which appeals most strongly to the imagination, and, without being carried away by the somewhat rhetorical enthusiasm of the motor manufacturer, the picture of a shop devoid of light-obstructing belting and belt shifters, oil-dripping hangers, and perverse main shafts is an



A BRUSH 4 H. P. MOVABLE MOTOR.

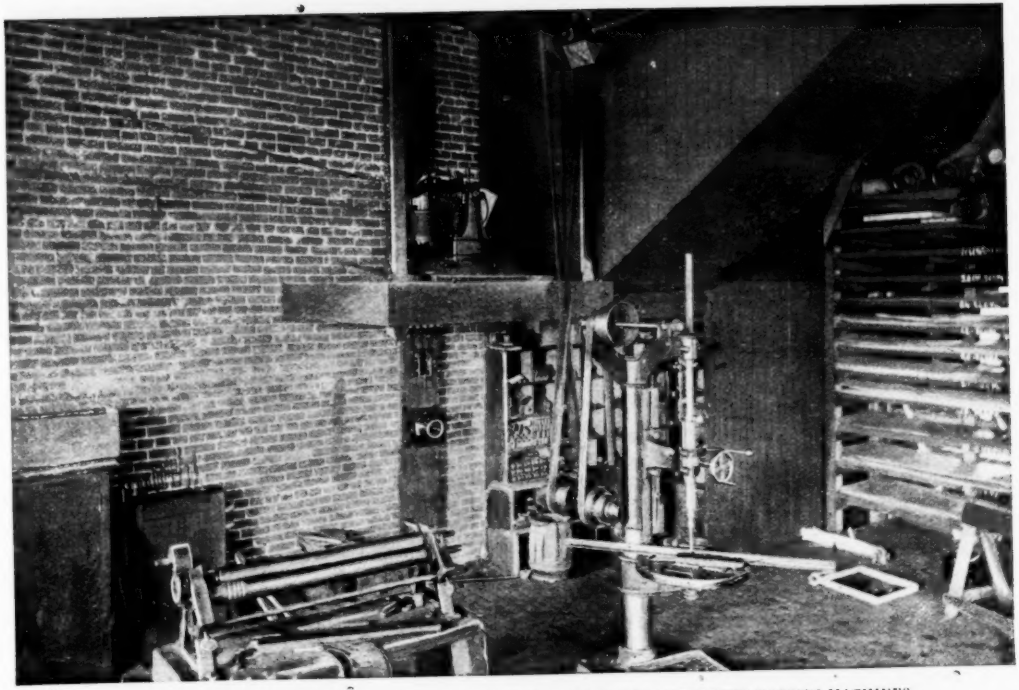


A LONG AND ALLSTATTER PUNCH DRIVEN BY ELECTRICITY.

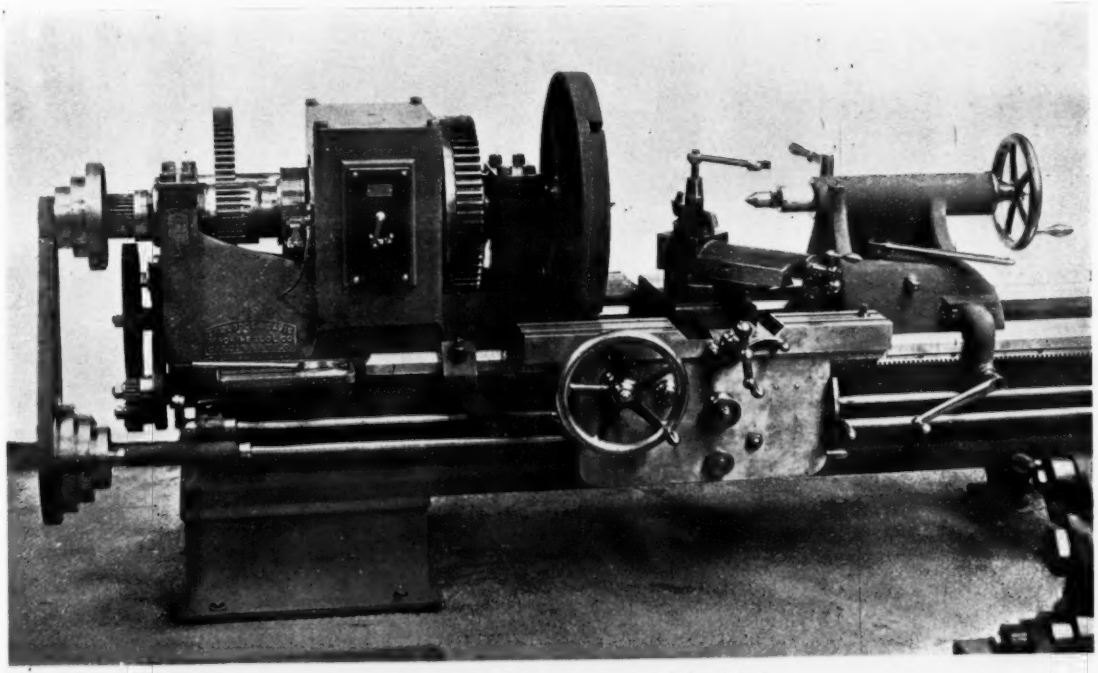
inviting one. We are even willing to admit that, when light traveling cranes run over all the tools, the workman will whip the work into and out of the lathe with incredible promptness, and that he will keep his hand on the regulator handle, following up the variations of cut with changes of speed so closely as to get more work out of his machine-tool than had ever been dreamed of in our old philosophy.

Many very neat arrangements have been made of tools and direct driving motors, several examples of which are given. Naturally rotating machinery, such as lathes and drilling machines, lend themselves most readily to such combinations, which up to the present are mostly the production of motor manufacturers. The direct driving of the planing machine, with the abolition of the cumbersome reversing gear, will present a problem of greater difficulty for the electrical and mechanical engineer.

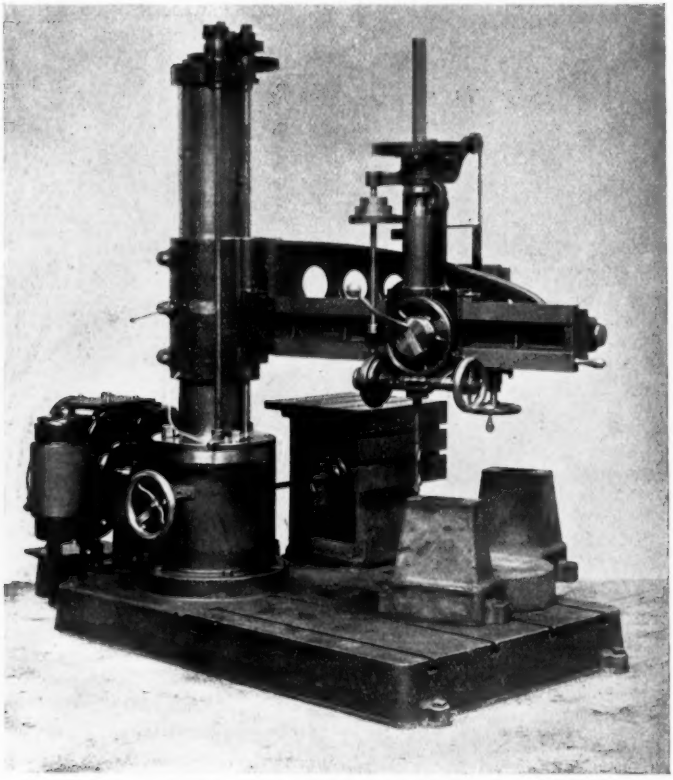
It cannot be questioned that there are many applications of the direct-driven machine-tool which fully justify the claims put forward for it. If it displaces a tool so remote from the engine-room as to require a special engine, the chances are that a comparison will give



SHOPS OF MARION STEAM SHOVEL CO.—GENERAL ELECTRIC MOTOR OPERATING VARIOUS MACHINES.



A LODGE AND DAVIS LATHE DRIVEN BY A CARD MOTOR.

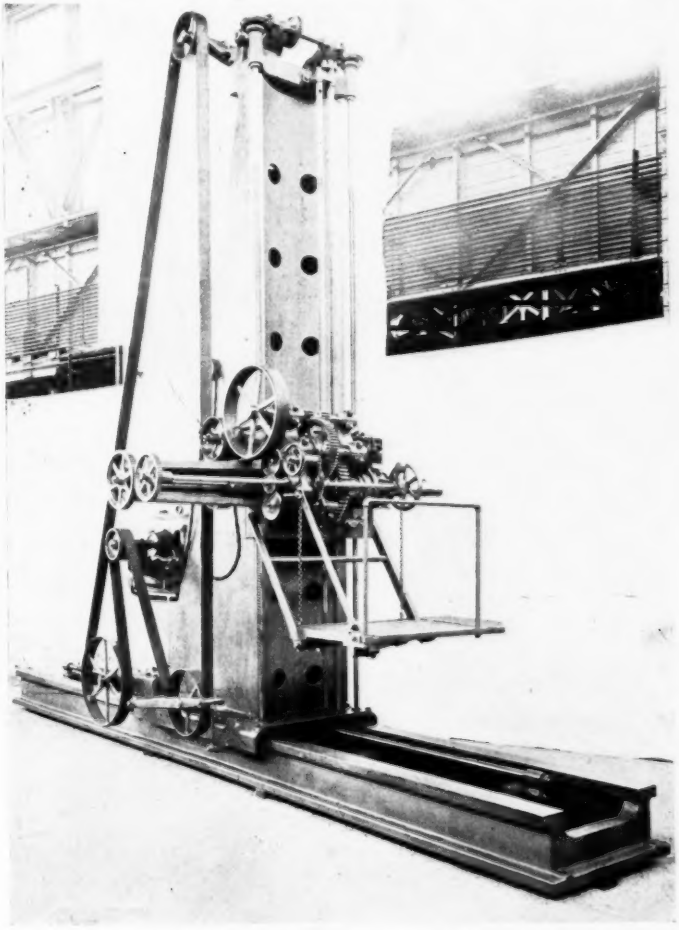


A CARD MOTOR OPERATING A RADIAL DRILL.

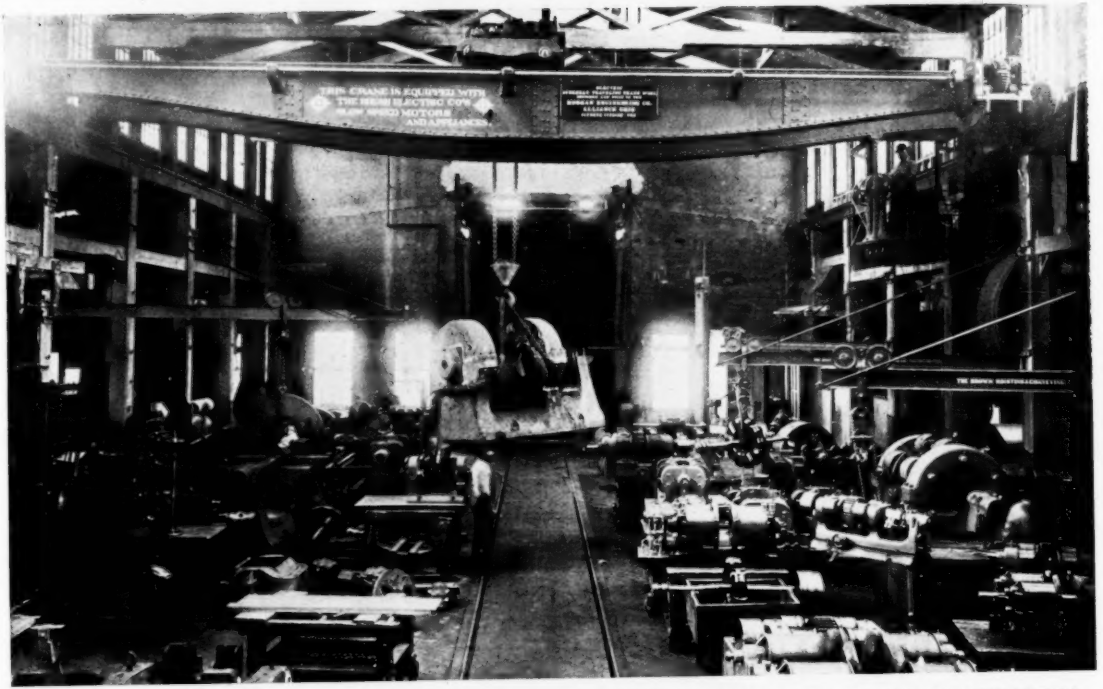
some very pretty figures, which, however, will have the proverbial falsity when applied to the case in hand,—namely, that of an ordinary machine shop furnished with directly-driven tools. For, in the present state of the art, it can hardly be seriously claimed that such a shop could be run with a less expenditure of motive power than one fitted up with reasonably efficient shaft transmission.

In an ordinary machine-shop the majority of the tools require a very small amount of power to run them under average conditions, nor does this amount of power vary so much as a casual glance at the belt connections would suggest. As the direct-coupled motor must be prepared to furnish the maximum power required, this means of

course that the motors are habitually run at considerably less than their rated capacity. With the increased use of direct-coupled machines statistics will no doubt be obtained as to the ratio between the maximum and average power required, for the observations will be comparatively easy to make. In the meantime the practice seems to be to provide a motor of ample capacity, and this in itself is a cause of some



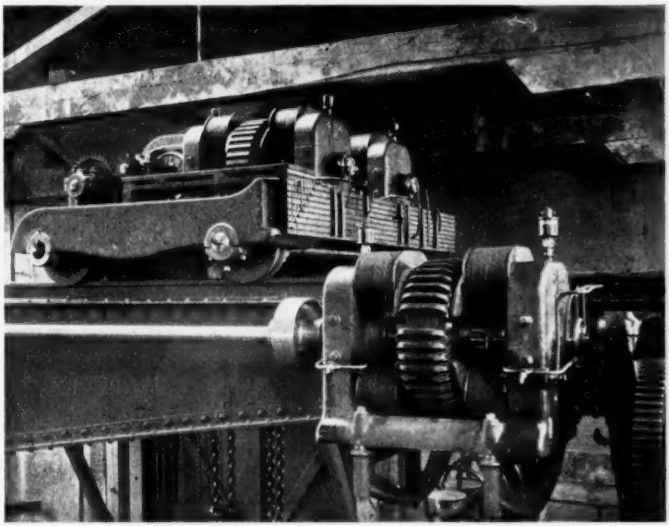
A SELLERS FLOOR BORING MACHINE AT CRAMP'S SHIP YARDS.



ERECTING DEPARTMENT, BRUSH ELECTRIC CO., CLEVELAND, SHOWING ELECTRIC OVERHEAD TRAVELING CRANE, CAPACITY 15 TONS.

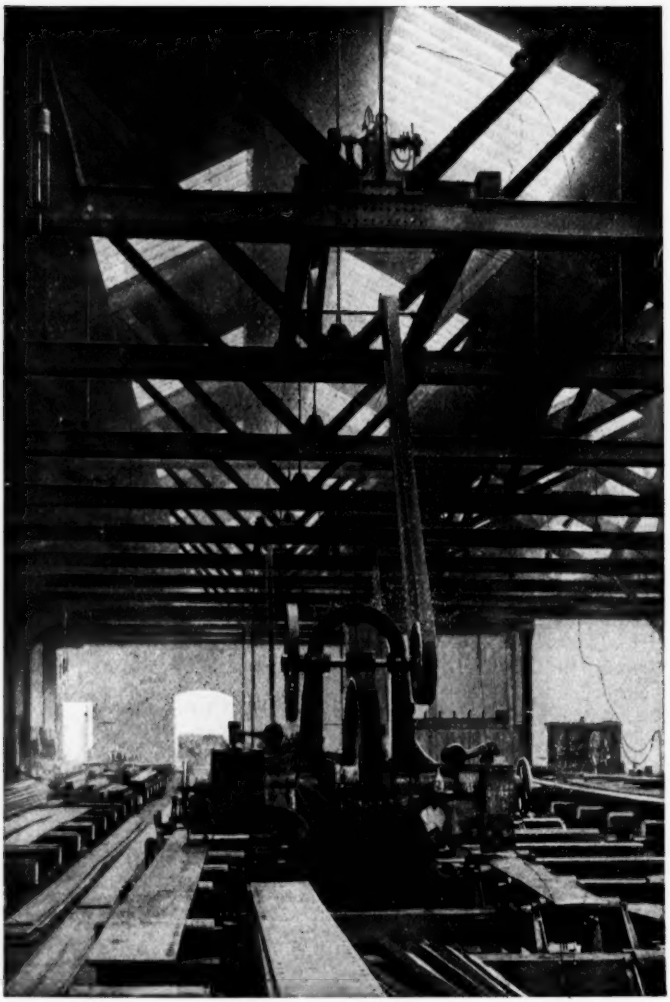
misgivings on the part of the machinist. He has a lively recollection of instances where the disastrous results of carelessness or inattention have been averted by the kindly habit the belt has of slipping or running off altogether when an unsolvable problem is presented to it, and the question arises whether the safety fuse can be depended on to the same extent under similar circumstances.

Assuming that the bulk of the machine-tools in the average shop require less than one horse-power each to run them, and that the motors are run at very much less than their rated capacity, it would at the present time be rash to expect from them a higher average efficiency than 60 or 70 per cent. The dynamo supplying the motors will also



BRUSH MOTORS OPERATING TRAVELING CRANE.—SEE PAGE 680.

be run under conditions unfavorable to maximum efficiency, the average power being considerably less than its rated capacity and fluctuating more or less violently. An efficiency, therefore, of 85 or 90 per cent. may be considered satisfactory for plants of moderate size. If we take the smaller efficiencies, then one horse-power utilized requires the furnishing of 1.96 horse-power by the engine. Allowing 2 per cent. for work wasted in the leads, we obtain as a result that 50 per cent. of the work delivered by the engine is absorbed in transmission. If we take the higher efficiencies,—namely, 90 per cent. for the generator and 70 per cent. for the motor,—then 1.6 horse-power must be



SHOPS OF WROUGHT IRON BRIDGE CO., GENERAL ELECTRIC MOTOR OPERATING PUNCH AND SHEAR.

furnished for every horse-power utilized, and, adding 2 per cent. for the leads, more than 27 per cent. of the work furnished by the engine is absorbed in transmission. If the time required to take care of the large number of motors employed were devoted to keeping the usual system of transmission in order, it cannot be doubted that in point of economy the advantage would remain with the latter.

It may be objected that the fact so often insisted on—namely, that, while the machine tool is not in operation, no work is being done on its account—has been ignored. This, though very important in some applications, is less so in the case of an ordinary machine shop where the majority of the tools are running with short intermission. Moreover, the stopping of the motor does not diminish the friction of either the engine or the generator; the saving therefore is at most the difference between the friction of the line shaft and that of the generator, since the countershaft connections could usually be cut off by suitable clutches if the saving effected were sufficient to warrant the expense.

For driving larger tools subject to intermittent use and distributed over a large area, electric transmission may be expected to make a better showing on the score of economy, besides securing the important advantage of a clear head-way. Such an installation was made by the late E. V. Clemens, while superintendent, in the erecting shop of the De La Vergne Refrigerating Machine Company, New York. When this was completed in 1892, some of the heavier tools were removed into it and adapted to operation by independent motors. The full advantage of direct coupling could not of course be obtained in this case, but the necessary countershafting is attached to the walls of the building below and well out of the range of action of the traveling crane.

The tools thus operated are as follows:—

10 × 10 × 30 feet Planer	15 H.P
15 feet Boring Mill	10 H.P
18 inch Slotter (2)	10 H.P
64 inch Corliss Boring Mill	10 H.P
Rumbler	3 H.P
Crane (2) 10	20 H.P
" (1) 5	5 H.P
Lathe	2 H.P
	75 H.P

All the motors are of the C & C type, running at about 1100 revolutions, the crane being the Morgan three-motor type, having a lifting capacity of 15 tons, a span of 52 feet, and a clear height of 24 feet 10 inches. The current is produced by two 40 horse-power Thomson-Houston generators run by a 100 horse-power vertical Hewes

& Phillips engine. In actual practice one generator is found to be sufficient, though it is rather severely taxed at periods when the crane is operated at the same time that the planing machine is run on a short cut. This latter machine was at first supplied by a 10 horse-power motor, but reversing was found to slow it up too much, notwithstanding the addition of a fly-wheel, so that a 15 horse-power motor was substituted. The table on page 685 represents the results of a trial extending over five weeks, giving the time run by each motor and the machine driven by it, the average horse-power delivered as determined from the Watt-meter, and average of these for the whole period. The indicated horse-power calculated as the average results of some 40 cards was 23.98. Although the times of taking the cards were arranged with a view of obtaining a fair average result, nothing short of a continuous record could, under the circumstances of fluctuation, give perfectly reliable results. That these were probably near the truth was considered to be shown by the fact that the friction of the engine generator, and intermediate connections, accounted for 13.4 horse-power of the 14.3 horse-power of missing work. It was intended to ascertain the amount of work consumed by each tool, but the observations were rendered of little value in consequence of a subsequently discovered defect in the instruments. However, the amount of work to be credited to any one machine (including the proportional amount of the loss in the leads) can be written down directly from the above table in the determinant form, the reduction of which however would probably involve more labor than the information is worth.

Before making any deductions from the facts here disclosed, it may be observed that, under the circumstances of the trial, a 50 horse-power engine would have been sufficient for the purpose, provision having been made for extending the plant. We may deduct say 6 horse-power from the lost work, so that 18 indicated horse-power would have been supplied. If we allow 6 horse-power for the friction of the engine itself, this leaves 12 horse-power furnished, of which 2.22 was consumed in the counter-shafting and dynamo and a further (probably small) amount in the leads. Considering the location of the machines, this may be considered a very fair showing in comparison with the cost of running shafting —and, in view of the convenience, eminently satisfactory. These figures cannot fail to suggest a solution which might reduce the first cost of such an installation, for, since less than 10 horse-power is called for on the average, why should not a 15 horse-power engine, with storage batteries, run it?

Neither the relative cost of installation nor that of maintenance have been discussed, for the reason that, while at the present day the

TEST OF THE ELECTRIC POWER PLANT OF THE DE LA VERGNE REFRIGERATING MACHINE COMPANY.

1892.	Average horse power from wattmeter.	RUNNING TIME OF MOTORS. Planer. h.	m.	Drill. h.	m.	Drill. h.	m.	Horizontal Drill. h.	m.	Slotter. h.	m.	Boring Mill. h.	m.	Crane. h.	m.	Working Time. h.	m.
Nov. 28	9.00	9	45	0	45	2	40	3	15	8	23			6	27	10	00
" 29	9.33	8	15	3	30	3	50	6	55	8	35			3	54	10	00
" 30	8.52	3	30	1	35	1	05	3	25	8	37	9	30	4	10	10	00
Dec. 1	10.93	8	00					4	20	8	01	2	50	4	59	10	00
" 2	8 11	7	30	1	00	2	20	6	15	8	16			4	32	10	00
" 3	9 35	7	15	3	05	2	30	6	15	7	15			4	22	8	45
" 4	Sunday																
" 5	8.11	7	00	0	45			3	55	7	17			7	55	9	55
" 6	7.88	7	45	1	05			6	20	7	55			6	09	10	00
" 7	8.69	8	35	0	50			5	15	9	35			5	23	10	00
" 8	9 33	9	25					6	35	8	48	1	40	6	10	10	00
" 9	11.09	9	00	2	00			7	15	8	37	4	10	7	09	10	00
" 10	9.47	7	15	0	45			6	15	8	27	4	30	5	09	9	00
" 11	Sunday																
" 12	10.13	7	04	5	00			5	55	8	32	1	30	7	21	10	00
" 13	9.30	6	21	5	00	1	20	7	35	9	35			6	14	10	00
" 14	8.35	9	08	0	30	5	25	7	55	8	24			4	41	10	00
" 15	9.15	7	39					5	45	9	22			6	34	10	00
" 16	9.00	6	37	1	30	2	35	7	00	8	32			7	03	10	00
" 17	10.47	6	35	1	00	0	30	6	45	8	25			3	56	8	45
" 18	Sunday																
" 19	9.97	9	05	3	00			7	55	8	22			7	05	10	00
" 20	9.65	8	40	2	00			7	00	9	40			7	35	10	00
" 21	9.25	8	40	0	55			5	05	8	22			8	20	9	55
" 22	8.09	7	20	1	40					7	47			6	40	9	55
" 23	10.61	7	40	2	25			6	50	8	25	1	05	6	39	10	00
" 24	11.08	5	43	3	10			5	20	8	12	6	45	5	10	9	00
" 25	Sunday																
" 26	Holiday																
" 27	14.00	8	10	3	50	2	05	7	55	8	12	6	30	8	30	10	00
" 28	10.13	6	26	4	20	2	00	7	45	9	29	2	55	8	05	10	00
" 29	9.47	8	25	1	50			5	05	7	20	2	10	7	00	10	00
" 30	10.61	10	00	1	20	3	45	6	15	8	22	2	51	6	50	10	00
" 31	11.98	9	00	2	05	1	55	5	30	8	19	2	05	6	35	9	00
Average	9.63	7	47	1	54	1	06	5	55	8	27	1	40	6	13		

equipment of direct coupled motors is undoubtedly more costly than shaft transmission, the difference will ultimately decrease very materially when the selling price of motors shall become more nearly related to the weight of metal employed in their construction : and, although the maintenance of several hundred motors may seem an appalling undertaking, we may reasonably expect that, when pursued systematically, especially in view of continued improvements, it will be found no worse than the constant vigilance required to keep shaft transmission in order, with its lining up of shafting, oiling of hangers, taking up and repairing of belting, etc.

The method of grouping a number of machines around a motor is at best only a transitory and temporary solution, and, while it may be employed with advantage under certain existing circumstances, it possesses few of the advantages of the direct coupled method and disadvantages of its own. It retains the use of belting and countershafting, and, when the motor fails, the whole group of machines dependent on it is brought to a standstill.

It is not believed, of course, that existing machine shops will reconstruct their plants to adopt the direct coupled method, but doubtless many such intermediate applications as that of the De La Vergne Refrigerating Machine Company, Fraser & Chalmers, and others will be made. If the collateral advantages claimed for independent driving are real, it is a matter of small moment whether the cost of running is greater or less than that of shaft transmission. If it can be demonstrated that materially more work is got out of the machine, this will be the controlling factor. The number of men employed per horse-power varies very much in different shops. The average of the ten cited is about three men per gross horse-power.

If an engine uses four pounds of coal at $3 per ton per horse-power, the cost of the latter per hour is 6 mills. To utilize this, if we allow 20 cents per hour as the average wage, 60 cents is paid in wages alone, leaving out interest on cost and depreciation of the tool. Thus *one per cent.* increase in the efficiency of the tool would compensate a doubling up of the total horse-power now employed on the average in the ten shops referred to. Hence the money value in any possible difference in the cost of transmission, sinks into insignificance before only a small percentage of increase in the efficiency of the tool.

Does direct electric coupling increase the efficiency of the tool, if so, to what extent? This is a proposition somewhat difficult to prove in view of the many elements entering into it, but it is one to which the advocates of the system must principally address themselves.

FIRST PRINCIPLES IN ARCHITECTURE.

SECOND PAPER.

By Prof. Wm. H. Goodyear.

THE last sentence of my previous article read originally, "The architect of the future is an engineer"—and therewith the paper ended.

Impressed by this sentence, the editor of THE ENGINEERING MAGAZINE has requested that I undertake to explain this sentiment, or to vindicate it. I take pleasure in responding to the invitation, but in doing so it becomes necessary to say that the reading of my preceding paper is almost essential to the proper understanding of the present one.

I have shown that our historic styles are none of them traditions which connect with the original historic past, and that consequently they have not profited by its experience,—that they are purely superficial imitations, which in themselves neither do much harm or much good. They do not do much good, because the superficial appearances of the supposed model, if they were virtues once, could not very well be virtues now, the conditions of life and culture being different. They do not do much harm, because genius and common sense are more or less superior to the self-deception which the very use of the term "historic style" seems to imply.

So far my editor considers my argument destructive rather than constructive. It points to certain inherent and necessary weaknesses in all architecture which rests on an ideal of imitating historic styles for literary, sentimental, and archæologic reasons.

Very well, then; what shall we do in a positive sense, if we are not to be literary? My answer is "We are not to be literary, but practical." If I am asked "How shall we be practical?" my answer is, "Be practical." If these answers be considered frivolous, I should then say "Educate the consumer, or the patron." In a word, "Educate the public." To put a little plainer point on it—"Stop blaming the architects."

I will take an example from last night's newspaper, in which it appeared that a mansion at Asheville, N. C., is "modeled after the château of Blois." On the strength of this piece of news the following questions suggest themselves. First, supposing the alleged news to be true, we observe that the newspaper does not say that the mansion is "alleged" to have been modeled after the château of Blois.

So far from guarding against a suit for libel, as is customary where news damaging to the reputation is printed, it does not appear that the news was supposed to be damaging either to the owner or architect of the mansion. If it were said by the same newspaper that Mr. Gilder had modeled his last poem after one of Shakespeare's sonnets, the word "alleged" would probably have appeared in the report, which otherwise would have been libelous in spirit, if not in law. Why should the architect hasten to announce what the man of letters would be anxious to conceal? The answer lies with the public, whose standard of style in literature is originality, and, in architecture—the want of it.

Second, still keeping to our concrete example, the question suggests itself: "If the mansion at Asheville be really modeled after the château of Blois, would it not be well to inquire what the château of Blois is modeled after?" If it should appear that the château of Blois is an original design, why should not the mansion at Asheville be another?

In this way of looking at things we should come to a curious result. If the architect of the Asheville mansion were talking to me, we should undoubtedly agree in considering the Asheville mansion an original design but, when he is talking to the owner of the mansion, it is "modeled after the château of Blois." A possible or probable thing is that the owner of the mansion, after visiting the château of Blois, thought that he would like to have another, ordered it, and was told that he got it and believed it, and got something a good deal better than if he had gotten what he ordered.

Is there an eminent architect in this world who does not know that *the frank exhibition* of construction is the one test of good architecture, that the first and main mission of ornament is to emphasize construction, and that the conditions of construction change with every new century of history? Hardly. Why, then, should I bleat this lesson in his ears?

Is there a man of common sense in this world who believes that the life of the sixteenth century is being lived at Asheville, N. C.? Hardly. Why, then, should I bleat the lesson in *his* ears that it is not being lived there?

Here comes the rub. The man of common sense knows nothing about art, because he does not know that art is common sense. Therefore I say "Educate the public."

No easy task that—and yet it is being done. Witness the transformation in American art between 1876 and 1894. What makes our task difficult? First and foremost, the specializing of pursuits and interests. I know nothing about chemistry, and my friend, who is a

chemist, can look at the entrance of the new Salvation Army building on 14th street without shuddering. The modern eye is dulled, blunted, and careless. It literally looks without seeing. Why should we goad our architects to a perfection which would not be recognized? In so far as certain human faculties are specialized, in so far are the other faculties atrophied. The man of the sixteenth century, or any earlier century since the Egyptians, was much more equably organized than the man of the nineteenth century. He did everything better, because he did not do so many things thoroughly. As literature and books have come in to supplant pictures and sculpture as educational instruments; as personal and private interests have come in to supplant public pride and civic patriotism,—so have the arts of form declined. To teach people to see we must first teach them to look. Even this is difficult in our age of hurry and pre-occupation. But we may at least complete the literary education we have begun. It is our pride to belong to the first century which has ever made a scientific study and conquest of history. As we were growing up to that conquest of history in the last three centuries, we stopped by the way, in our enthusiasm for Rome and Greece and the Gothic communes, to imitate even their buildings. We have carried these studies farther and deeper, till, as historic students, we see that this imitation was an absurdity, a grotesque abortion of the original, an injustice to ourselves. This is the present knowledge of the historic student; let that too pass to the public which has learned so much of history already. And here comes in the fatal weakness of the mansion "which is modeled after the château of Blois." It does not, alas! represent an enthusiasm for the sixteenth century and Francis I. That much at least in a corresponding sense did our earlier modern Roman and Greek and Gothic do, for the given time which was imitated. An honest enthusiasm for history at least was there. Not so at Asheville. Even the tradition of a tradition has paled, and man does what he did do—not even with the virtue of committing a good, honest mistake. His predecessor was a student of history, who made the mistake of an enthusiasm for history. *He* is living in a time when history is a science and not an enthusiasm; *he* is not an enthusiast and not a historian; and yet he is doing, or rather only pretending to do, what an enthusiast did *because* he was a historian. Of all things on earth I am fondest of the opera bouffe. That is why I like the nineteenth century which alone produced it.

To come back then to our programme for practical improvement. To teach the public its errors of theory and conception is to do something practical. When that is done, let the architects do the rest. It is their affair, not mine.

To the public and not to the architect I address myself in the following hints. You are beginning to travel and to admire historic buildings. Your next business is to find out *why* they are admirable. When you have found that out, you will never admire a copy—*because* it is a copy; and your reporter will never put in your newspaper that your mansion is modeled after the château of Blois, unless he wishes to hurt your feelings—which we know that he occasionally *does* wish to do.

Consider the possibilities and proprieties of architecture according to location and destination. The problem which interests an architect is the problem of designing a building which can be seen on all sides,—where masses can be balanced and contrasted, and effects built up by masses. The problem of a façade for a pretentious city building, cooped up between other buildings,—a mere front,—is, properly speaking, no problem at all. The best way to solve it is not to try.

Architecture is not advertising. Do not advertise your bank or your insurance building by a pretentious façade; because every art work is a failure that tries to advertise. Every person of cultivated architectural taste is pleased by large expanses of masonry surface, and is willing to be satisfied with them. Hence our best city efforts are apt to be the armories and storage buildings, where common sense still calls for simplicity. Whatever ornamental treatment is given to the building material should in the first place develop the ideas of the necessary construction. Your main constructive lines in a business front are the lines of the stories and of the roof. Do not obscure these lines by so-called architecture. Do not allow cornices as heavy as the roof cornice on the other stories of your building. If the building is a sky-scraper, do not be ashamed of it, but glory in it. The higher the building the better—and the higher it looks the better. No need to bind stories together and obliterate them by a "tasteful composition" because the building is high.

City architecture, so far as it consists of dwelling houses, stores, warehouses, and other business buildings, in solid blocks, should rest satisfied with great simplicity. If our business men were content to let their buildings reflect their own business qualities and business character, the calling of the critic would disappear. All art is satisfactory as it corresponds with character—with utility. If a people is frivolous, ostentatious, and pretentious, its architecture will reflect these traits; but we know that business men do not reach success by anything but business qualities. Let them be as economical in exterior show as they are in paying their book-keepers and office-boys, and New York city would be a paradise for my feeling. Let them be as bold in their choice of a façade composition as they are in making a Wall street corner, and our architecture would rival the Egyptian.

Let the man of business avoid expensive pediments and broken cornice lines as he avoids a bad debt. One may be as expensive as the other. Both are bad debts. One may be forgotten, but the other is always staring us in the face. As far as I am concerned, the sense of wasted money, and money wasted by men who are supposed to be experts in keeping it, is what I get from pretentious shop and bank façades. Our brokers and bankers and shop-keepers are not heroes; they are not men of science; sometimes they are not even statesmen; but they are supposed to be men of business. Why, then, should their architecture not be business?

In this matter of stern and simple reticence in business buildings, Chicago is far superior to New York, and to Philadelphia. Possibly it was compulsion dating from the time of the fire. The odd thing is that good architecture has always very largely been compulsion. The architrave and frieze which we have borrowed from the Greeks and Romans and scattered in ornamental copy over the fronts of our buildings was compulsion to the Egyptian, because he used in temples a flat stone roof which rested on one line of stone beams, and was faced in front by another. The buttress and pointed arch were compulsion to the Gothic architect; his building would have tumbled down without them. When there is no more money to waste, and banks and insurance companies are run on a closer margin, I look for a great improvement in New York.

These, then, are my views for cities about architecture in blocks of any kind. Stated briefly, they are "Don't have any"—Punch's advice to people about to get married: "Don't." What the cultivated eye is looking for is general effect. If we are to get any general effect in our crowded streets of buildings of unequal height and unequal width, it must be, first, by repose of surfaces; second, by abandoning the system of cornices devised for one point of view and seen from fifty; third, by shadow effects of doors and windows which are not tormented with projected canopies and pediments; fourth, by the picturesque irregularity of one building as against another. This irregularity can only be picturesque when there is some sort of correspondence in appearance between the front and the sides of a building. A more truly ludicrous spectacle is not to be seen in the world than our series of pretentious façades with heavily projected cornices and moldings, as facing on the street and designed for front view—not worth much at that—and rearing a series of side walls which are politely considered outside the problem of the architect, because some other time some other fellow is going to cover them up. In heaven's name, if so thoughtful of economy on the sides, give us a little of this economy in front. Street lines of medieval houses closely

packed are still to be seen in many European towns. They are delightfully picturesque, simply because the irregular fronts are as unpretentious as the irregular sides.

No doubt our city block architecture, business or domestic, suffers from three causes—ostentation, advertising effort, and honest ignorance; bad taste, that is, which might be improved by taste education. The ostentation and the advertising effort go back to traits of character and culture with which the art critic has no business to grapple, because they are wholly incurable. On the other hand, no expert can deny that we have witnessed in the last twenty years a magnificent improvement in the points on which I take issue with city block architecture. The whole Queen Anne, Italian Gothic, and Romanesque movement has really been a movement for plain masonry surface and the abandonment of projected detail. Oases of refinement can be picked out all over New York city in the architecture of the solid blocks, and I leave it to other critics to say if these oases are not generally marked by simple reticence, aside from those little traits of refinement in detail which, like the tone of the voice or the expression of the face, denote the person of culture.

We will turn next to the problem of public buildings,—buildings which stand free and can be seen on all sides. It is conceded that our government buildings—municipal, State, or national—are, generally speaking, our worst efforts. Americans are apt to be "agin the government" and are always willing to laugh at themselves if the government is in fault. This is possibly not an advantage. It does not favor improvement. It is pretty generally understood that many of our United States buildings have been designed by West Point officers, which is equal to saying that they are wholly out of touch with the new movement in architecture. It is in the matter of public buildings that we begin to raise comparison with older architecture. The problems of our city block architecture are partly new, but the only way to solve them is not to try. This is what the ancients and the Middle Ages did. When we come to public buildings, comparison with the past is inevitable. We will now say this general word on modern architecture. Its weakness is anxiety,—trying too hard. It is only supreme genius which can make an effort to conquer attention without suffering from the weakness of effect which goes with the sense of effort. Literature, the stage, and the art of the painter and sculptor all teach one lesson. Repose is always success, and it is always success because it always represents a sense of power. Lack of repose is shown in personal conduct by over-affability or by over-dress. The one general defect of all modern architecture is the anxiety to please (and, let us add, the anxiety to please the wrong people).

Much of our modern building makes the same impression on me which I receive from an over-dressed person. Now, repose is power, but it is power which may rise to a supreme effort, sure of success and therefore certain to achieve it. For that too conquers the attention, —that the artist knows he can succeed. The brilliant beauty of the ballroom is never over-dressed; but let the woman who does not realize her power, or who has none, wear the same dress, and the woman is over-dressed. Now, the force of character which means power in building, or elsewhere, means repose in general; but it also means supreme and triumphant effort. The streets of Athens were bare walls in the days which built the Parthenon. The streets of Rouen were timber and plastered walls when its Gothic churches rose to power. Modern architecture shows by its pretentious street façades why it is not over-successful in public buildings. Character and public spirit are both wanting to us by contrast with older days. What absurdity to ask of an architect the character which we do not possess ourselves! None the less do the Pittsburgh court house, the Albany town hall, and the Hartford capitol, and many other buildings, show that we are not all or wholly weaklings in these later days.

The one grand law of all public as of all private architecture is to begin by planning the interior. The exterior which corresponds to that interior is and must be right, if the interior meets the problems of its natural use. Once more I come back to my theme that it is the public, and not the architects, which needs education. As long as the public considers simplicity severe and prison-like; as long as the public does not know good color in brick or good detail in stone; as long as the public wants its mansion modeled after the château of Blois,—why worry the architect with articles in the magazines? I am sure I should not do it if I had not been asked.

We come at last to our most hopeful topic,—the country-house architecture of America. Doubtless here, too, there is much over-striving and over-effort; but no one can ride around the suburban places which surround our cities without feeling that an immense amount of refinement, of character, of individuality, of artistic taste, and of honest hard work has gone into American architecture in the last twenty-five years. Is this partly because the decorative art movement has had fuller sway here? I think so. Whatever be the causes, the fact is there,—that American country-house architecture leads the world and claims the first place (according to my view) in all modern architecture.

Among the causes we may suggest the following: the absence of the business advertising idea; the absence (generally speaking) of the ostentatious element; the influence of feminine good taste; the nec-

essary exercise of individual discrimination in the matter of plans and arrangement; the necessary reflex in the variety of lines, masses, and shadows of the exterior; the fact that the architect *can* design an exterior, and does not have to design a mere front. If I were to add a crowning cause of the success, I should consider it to lie in the absence of that soul-crippling theory of historic styles which has ruined our city architecture; for who does not know that "Queen Anne" and "Colonial" are convenient fibs of the architect who is called on to name the "style" supposed to be chosen for the country house.

A last word as to principles of taste in architecture. In dress, in utensils, in furniture, and in buildings, we only recognize one law for ornament,—viz., emphasis on the facts which ought to be emphasized. Points of support and of pressure, joints and connections, seams, borders, outlines, terminal points and terminal lines—these are the things to be brought out by ornamental detail. Construction may be exhibited frankly, or the interior facts may be brought out by exterior suggestion. Compare the treatment of the lines of the stories on the Florentine Strozzi palace, wh ch suggest the facts regarding the main interior stories, although these lines are not in construction connected with them. That form is pleasing to good taste which shows and reveals its use. That form reveals the use most successfully whose surface and outlines, and whose skeleton or frame, speak for themselves, and are not obscured by misplaced ornament. In dwelling on the power of surfaces we must not forget the power of shadows and of their contrast with surfaces. Given the knowledge and practice of these elementary principles, much lies in genius, in artistic temperament, even in occasional caprice; but these are the dressing of the salad, not its body or solid contents.

I have said in the conclusion of my last paper that the architect of the future is an engineer. Every engineer is an architect now. When every architect is an engineer,—that is to say, a designer of construction who is not ashamed of his construction,—the problem of modern architecture will have been solved, and the architectural critic will be as useless as training schools for artists would have been in the time of Phidias, or lectures on historic ornament in the cities of the Byzantine empire.

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A S M E. Am. Soc. of Mec. Eng. *m.* New York.
B..... The Builder. *w.* 26*s.* London.
B A... .The British Architect. *w.* 23*s.* 8*d.* London.
B B.....Brick Builder. *m.* $2.50. Boston.
B I S . .Bul. Am. Iron and St. Asso. *w.* $4. Phila
B J C....Boston Jour. of Commerce. *w.* $3. Boston.
B M ....Banker's Mag. *m.* 18*s.* London.
B T J ...Board of Trade Journal. *m.* 6*s.* London.
B U W .Bul. of the Univ. of Wisconsin.
C A.....Calif. Architect. *m.* $3. San Francisco.
Can A.. Canadian Architect. *m.* $2. Toronto.
C & B... Carpentry and Building. *m.* $1. New York.
C E .....Colliery Engineer. *m.* $2. Scranton, Pa.
C Eng....Canadian Engineer. *m.* $1. Montreal.
C G. ..Colliery Guardian. *w.* 27*s.* 6*d.* London.
Ch.....Chautauquan. *m.* $2. Meadville, Pa.
C M.....Century Magazine. *m.* $4. New York.
C M R..Canadian Mining Rev. *m.* $1.50. Ottawa.
Cos.....Cosmopolitan. *m.* $1.50. New York.
C R.....Contemporary Review. *m.* $4.50. London.
C T J....Chem. Trade Jour. *w.* 12*s.* 6*d.* Manchester.
D E.....Domestic Engineering. *m.* $2. Chicago.
E.....Engineering. *w.* 36*s.* London.
E A.....Electrical Age. *w.* $3. New York.
E A S....Eng. Asso of the South. *m.* $3. Nashville.
E E .....Electrical Engineering. *m.* $1. Chicago.
E E L....Electrical Engineer. *w.* 19*s.* 6*d.* London.
E E N Y..Electrical Engineer. *w.* $3. New York.

E G.....Engineers' Gazette. *m.* 8*s.* London.
E I.....Electrical Industries. *m.* $1. Chicago.
E L.....Electricity. *w.* 7*s.* 6*d.* London.
El.. .....Electrician. *w.* 24*s.* London.
E M.....Engineering Mechanics. *m.* $2. Phila.
E Mag...Engineering Magazine. *m.* $3. New York.
E M J....Eng. and Mining Journal. *w.* $5. N.Y.
E N.....Engineering News. *w.* $5. New York.
Eng.....Engineer. *s-m.* $2.50. New York.
EngL... Engineer. *w.* 36*s.* London.
E N Y....Electricity. *w.* $2.50. New York.
E P.....Electrical Plant. *m.* 6*s.* London.
E R.....Engineering Record. *w.* $5. New York.
E Rev....Engineering Review. *m.* 7*s.* London.
E R L.....Electrical Review. *w.* 21*s.* 8*d.* London.
E R N Y..Electrical Review. *w.* $3. New York.
E S W P...Proc. Eng. So. of W. Pa. *m.* $7. Pittsburg.
E W.....Electrical World. *w.* $3. New York.
F ... .Forum. *m.* $3. New York.
F D.....The Foundry. *m.* $1. Detroit.
F R.....Fortnightly Review. *m.* $4.50. London.
F W.....Fire and Water. *w.* $3. New York.
F'y.....Fairplay. *w.* 32*s.* 6*d.* London.
G E M...Gas Engrs' Mag. *m.* 6*s.* 6*d.* Birmingham.
G & F....Garden and Forest. *w.* $4. New York.
G M.....The Geol. Mag. *m.* 18*s.* London.
G R.....Good Roads. *m.* $1. New York.
G W.....Gas World. *w.* 13*s.* London.
H & V...Heating and Ventilation. *m.* $1. N. Y.
I A.....Inland Architect. *m.* $5. Chicago.
I Age....Inventive Age. *s-m.* $1. Washington.
I & I.....Industries and Iron. *w.* £1. London.
I & S.....Iron & Steel Trades' Jour. *w.* 25*s.* Lond
I C B.... .Carpenter and Builder. *w.* 8*s.* 8*d.* London.
I C T... ..Iron and Coal Trades. *w.* 30*s.* 4*d.* London.
I E.....Indian Engineering. *w.* 18 Rs. Calcutta.
I I G.....Iron Ind. Gazette. *m.* $1.50. Buffalo.
Inv.....Invention. *w.* 11*s.* London.
Ir Age..Iron Age. *w.* $4.50. New York.
Irm.. ...The Ironmonger. *w.* 10*s.* London.
I R W...India Rubber World. *m.* $3. New York.
I S F.....Industry. *m.* $2. San Francisco.
I T R....Iron Trade Review. *w.* $3. Cleveland.
J A C S..Jour. Am. Chem. So. *m.* $5. Easton.
J A E S..Jour. Assoc. Eng. Soc. *m.* $3. Chicago.
J A N E..Jour. Am. Soc. Naval Engineers. *qr.* $5. Washington.
J F I.....Jour. Franklin Institute. *m* $5. Phila.
J G L.....Journal of Gas Lighting. *w.* London.
J M W A.Jour. of United Metal Workers of America. *w.* $1. N. Y.
J N E W.Jour. N. E Waterw. As. *q.* $2. New London.
J P E.....Jour. Polit. Economy. *q.* $3. Chicago.
J S A.....Journal of the So. of Arts. *w.* London.
L A.....The Landscape Architect. *m* $1.50. Rochester.
L E.....Locomotive Engineering. *m.* $2. N. Y.
L. H. P..Light, Heat and Power. *m.* $3. Phila.
M.....Machinery. *m.* 9*s.* London.
M A . ..Machinery. *m.* 50 cts. N. Y.
M & B...Manufacturer and Builder. *m.* $1.50. N. Y.
M E .....Marine Engineer. *m.* 7*s.* 6*d.* London.
Met W...Metal Worker. *w.* $2. N. Y.
Mill.....Milling. *m.* $2. Chicago.
Min. R...The Mining Review. *w.* $2. Denver.
M I T....Mining Industry. *w.* $3. Denver.
Min W..The Mining World. *w.* 21*s.* London.
M J.....The Mining Jour. *w.* £1. 8*s.* London.
Mo ...The Monist. *qr.* $2. Chicago.
M R .....Manufacturer's Record. *w.* $4. Baltimore.
M S P....Min. and Sci. Press. *w.* $3. San Francisco.
M W.....Mechanical World. *w.* 8*s.* 8*d.* London.
N..... Nature. *w.* $7. London.
N A R...North American Review. *m.* $5. N. Y.
N B .....National Builder. *m.* $3. Chicago.
N C.....Nineteenth Century. *m.* $4.50 London.
N C B...National Car Builder. *m.* $2. New York.
N S R....The New Science Review. *qr.* $2. N. Y.
N W.....Nowest. Architect. *m.* $3. Minneapolis.
P..... ..Paving. & Mun. Eng. *m.* $2. Indianapolis.
P A.....Progressive Age. *s-m.* $3. New York.
P E C P.Procd. Engineer's Club. *q.* $2. Phila.
P Eng...Practical Engineer. *w.* 10*s.* London.
Pl D.....Plumber and Decor. *m.* 6*s.* 6*d.* London.
Pr.....Power. *m.* $1. N. Y.
P S M....Popular Science Monthly. *m.* $5. N. Y.
R A.....Railway Age. *w.* $4. Chicago.
R C J...Railroad Car Journal. *m.* $1. New York.
R E M....Railway Engineering and Mechanics. *m.* $1. Chicago.
R G .....Railroad Gazette. *w.* $4.20. N. Y.
R of R...Review of Reviews. *m.* $2.50. New York
R P L....The Railway Press. *m.* 7*s.* London.
R R.....Railway Review. *w.* $2. Chicago.
R W.....Railway World. *m.* 5*s.* London.
Ry T.. . The Railway Times. £1. 5*s.* London.
S ... .Stone. *m.* $2. Chicago.
S A.....Southern Architect. *m.* $2. Atlanta.
San.....Sanitarian. *m.* $4. Brooklyn.
Sc A ....Scientific American. *w.* $3. New York.
Sc A S...Scientific Am. Supplement. *w.* $5. N. Y.
Sc M....Scribner's Magazine. *m.* $3. New York.
Sc Q.....Scientific Quarterly. *q.* $2. Golden, Col
S E .....Stationary Engineer. *m.* $1. Chicago.
Sea.....Seaboard. *w.* $2. New York.
S In.....Stevens' Indicator. *qr.* $1.50. Hoboken.
S J E....Sibley Jour. of Eng. *m.* $2. Ithaca, N. Y
S L.....Steamship. *m* Leith, Scotland.
S M.....Scientific Machinist. *s-m.* $1.50. Cleveland, O.
S M Q....School of Mines Quarterly. $2. N. Y.
S .....Sanitary Record. *m.* 10*s.* London.
S R E N..St. R'y. Elec. News. *m.* $2. Minneapolis
S P.....Sanitary Plumber. *s-m.* $2. New York.
S R G....Street Railway Gazette. *w.* $3. Chicago.
S R J....Street Railway Journal. *m.* $4. New York.
S R R.. .Street Railway Review. *m.* $2. Chicago.
S V.....Safety Valve. *m.* $1. New York.
T ... .Tradesman. *s-m.* $2. Chattanooga, Tenn.
T A I E E.Trans. Am. Ins. Elec. Eng. *m.* $5. N. Y.
T C E....Trans. Am. Soc. Civil Eng. *m.* $10. N. Y.
T Q.....Technology Quarterly. $3. Boston.
Tr.....Transport. *w.* £1. 5*s.* London.
Tr A M E.Trans. Am. Ins. of Mining Eng. N. Y.
T W A .Trans. of the Wis. Acad. Madison.
W A....Western America. *m.* $1. Omaha.
W E.....Western Electrician. *w.* $3. Chicago.
W R ....Westminster Review. *m.* $4.50. London.

ARCHITECTURE & BUILDING

Great Railway Stations of London.

LONDON railway stations are treated wholly from an architectural standpoint in *The Architect* (London, Nov. 2) in the first number of a series of articles upon the subject. These huge structures which form termini to the great English trunk lines have an architectural interest aside from their special characteristics, arising from the fact that important railway stations have often been made the subject of prize competitions for students of English architectural societies, and at the Royal Academy. "Some of the conceptions elicited, have been awarded medals, and were really excellent. Notwithstanding this encouragement to design of a high order in railway stations, their results appear to have been very meager, so far as the attainment of general architectural excellence in this class of structures is concerned.

"In London of recent years, with the rare exception of the Midland Railway terminus at St. Pancras, and quite lately with the extension of the Great Eastern terminus, the directors, in the assumed interest of the shareholders, have generally insisted on cutting down the architectural part of these overgrown 'sheds' while money has been freely expended on other parts of the building where it was supposed the outlay would 'pay.' At the same time, in the early part of railway enterprise, it must not be forgotten how far otherwise it was, as at Euston, in the great entrance carriage portico, and in the central hall also at Paddington, and to some extent at King's Cross. On the Continent the principal façade and general exterior of the principal stations in cities and towns has had the distinct advantage of being the work of an architect; at any rate the engineer has been materially helped in the art part by the former. The enormous hotels, which in several of the London termini entirely mask the railway station behind, are not so commonly found abroad in this situation, so that the outward suggestion of the internal arrangement is more often patent, which certainly is an advantage."

These points of arrival and departure are among "the more important factors of national life." The large majority of the population constantly resort to them for business or pleasure, and being legally public resorts for orderly people, it would seem that here, if anywhere, a reason for good architectural design exists, and that an opportunity for its exercise should be afforded.

The Great Western terminus at Paddington has no architectural pretensions. Both its site and its design combine to defeat any such intent, if the latter ever existed. It stands on low ground, and like most of the other large London stations "one or at most two of its sides are visible to the general public." The interiors have therefore more architectural interest than the exteriors. In describing the ground plans the terms commonly applied to ecclesiastical architecture have have been adopted for convenience.

"In the case of this building, the plan consists of a wide nave and narrow aisles, having span roofs and two transept-like roofs in the total length. As the north and south ends of the transept ends are flush with the sides of the aisles, the term must be taken in rather a Pickwickian sense. There seems no particular object beyond appearance in this arrangement, which must be more expensive constructionally than running the nave and aisles east to west continuously, like the ordinary plan of Gothic churches. But the writer has often admired its effectiveness and the very striking look of the great diagonal ribs at the junction of the several roofs. Though the nave or central roof is considerably wider than the aisles, the roof construction is the same, being that of a series of arched flanged iron trusses (without any tie-rods) set not far apart, the principals being

occasionally perforated by quartrefoils and other geometrical forms, and only panelled near the springing-line with ornament of a semi-Gothic, semi-Moorish character. The upper part of the roof is glazed on that useful plan, the ridge-and-furrow construction. The late Owen Jones was wisely consulted by the promoters in its decorative features, and though one of the earliest built, it still well passes muster as compared with later examples of the London terminus."

What is styled "the more modern idea," has been "fostered by the ambition of railway directors, and arose from the enterprise of civil engineers." This idea is "to roof all in one span." This has introduced "unnecessary difficulties such as would not have occurred had more subdivisions of the width been adopted. The idea of inclosing all under one by roof was a pretty one, but in practice it will be found that the placing of intermediate supports necessitated by several spans causes no inconvenience, as is evident on inspecting some of the large London stations. Possibly smoke and steam hang less about the large one-span roofs than in the subdivided ones. On the other hand there is the disadvantage that in the former type the size of the huge roof destroys the scale of everything near and beneath it.

"The terminus of the Great Northern railway at King's Cross certainly has nothing whatever meretricious in the design of its façade, which is honest and plain enough in all truth, built substantially of stock brick without any other material being used. There is the clock turret in the center, of campanile-like character, and what some ultrapurists would call that dreadful 'sham,' for all else is mere front. But in this case everything is transparent, for any one can peep through the big arched glass panels at the south side of the station and see the horizontal cornice sailing serenely above, regardless of what is obviously beneath and behind. Who is the worse for this? Who is deceived, speaking artistically? Nobody of course. Though treated in a rather crude way, this façade is a good example of that gentle veiling of what in all likelihood would have been an ugly termination, considering the ordinary section of a station roof. Those two arches of great width at the front of this two-aisled terminus, with their several brick rings and orders, were considered a marvel when built, and even now arrest the attention of those who use their eyes. The writer is of decided opinion that in these immense stations, with the large-spanned roofs of the customary type, it is better to make the ends as done here, or by a hotel or other buildings, so as to effectually stop the big unmanageable shed end."

The Granite City.

SCOTCH granite is noted the world over for its enduring qualities and its beautiful texture. Very few stones suitable for building or for monuments take a more elegant polish or present a finer appearance when polished. Its weathering quality is so much superior to that of marble that it has very largely replaced the latter in American cemeteries, and very fine effects in modern architecture have been obtained by the use of this material. The city of Aberdeen, in Scotland, is the center of the Scotch granite trade, and it is practically a city of granite. *Stone*, which gives in its November number an illustrated description of the "Granite City," as it is called, and of the trade in granite, its chief commerce, says it is "one of the best built cities in the wide world." "Its principal street (Union) is a thoroughfare of which any great capital might be proud." However, in the mists and storms which frequently visit that part of Scotland, "a city built of gray granite and roofed with black slate is not enchanting." Seen under aspects of sunshine, or moonlight, the city would probably present a less somber appearance.

The granite of which the city is built is obtained from the celebrated Kenmay quarries, which lie about seventy miles distant. "The largest of these quarries is 300 feet in depth and is worked by means of a gigantic crane and a 'blondin,'" the latter being a wire rope stretched over a quarry at an incline. On this is run an attachment which can be placed in any

position, underneath the rope, or it can be lowered into the quarry below. The stone obtained from this quarry is gray, flecked with light brown.

Other quarries are the Dancing Cairns —stone a light blue or grayish tint, the Rubislaw, whose product is grayish blue in color and very fine grained, the Peterhead, forty-four miles from Aberdeen, producing red granite of extremely fine quality, the Hill O' Fare, yielding dark red fine grained stone, and the Corrennie, whose output is of pale salmon color, much esteemed in some quarters, and stated to be always in good demand.

"Every stone mason in Aberdeen is a granite-cutter. Needs must be when granite is the one material out of which all masonry is worked. As a consequence the firms who cut to polish have the pick of some 3000 men, of whom they can give employment to about one-half. The remainder are engaged in various building operations. About 600 men are engaged as polishers. The masons are at present paid 6½d. per hour in the yards. They get 7½d. outside, but prefer constant occupation under cover at the lower wage to precarious employment liable to weather interruption outside. The polishers are paid from 4½d. to 5d per hour.

"By a rule of the Stone Masons' Union no firm is allowed to employ a greater number of apprentices than it has masons engaged."

Of late years trade with America has developed fast. The exports have valued thus:

1880	£12,000
1884	26,000
1892	67,000
1893	69,000

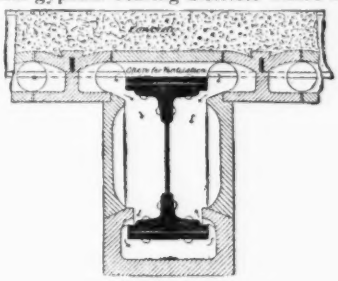
At present all agree that the trade is improved. The lowest price ever reached was in the early part of 1894.

Gypsum as a Fire-proof Material.

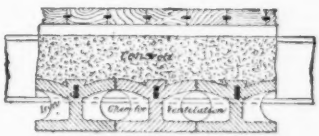
A NEW system of fire-proofing has recently been devised in England, and it appears to possess merit. This system is described with a discussion of gypsum as a fire-proof material in *The Illustrated Carpenter and Builder* (London, Nov. 2), with illustrations herewith reproduced.

Notwithstanding the extensive use, and general good qualities of gypsum as a fire-proof material, it has one marked defect, namely, that when used in large masses its expansibility is so great as sometimes to cause serious injury to buildings in which it is employed.

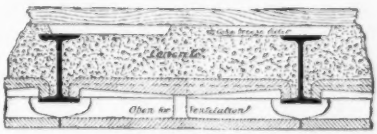
"The conductivity of gypsum is one-fourth only of slate, and less than one-half of fire bricks, the relative conducting power of the three materials cited being as 1000 for slate to 620 for fire-brick and 250 for gypsum. In Nottingham and Paris, and other gypsum-bearing districts where that



CASING TO MAIN GIRDERS.



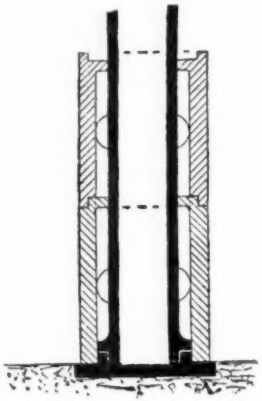
FLOOR, CROSS SECTION.



LONGITUDINAL SECTION.

material is used, destruction of buildings by fire is practically unknown. Gypsum was the only material found capable of withstanding the fierce fires in Paris during the Communistic outbreak—fires which were unparalleled in intensity. Mr. R. W. Edis, F. S. A., who was in Paris at the time, and made a minute examination of the ruins, reported to the Congress of British Architects in 1872 that generally throughout all the buildings it was evident that good plaster work, either in walls or ceilings, invariably protected and saved in a great measure materials it covered, and in many cases, while externally the lime-

stone walls had been broken about and calcined by the fire, internally, where plastered, they had suffered comparatively little. Evidence of this kind is beyond dispute. M. Louvier, architect, of Lyons, tested the fire resisting properties of gypsum. A rolled iron joist was placed under a slab of gypsum, and kept at a welding heat by means of a portable forge for more than half an hour without any more than the outer crust being affected, while the



SECTION OF COLUMN.

strength of the material was not injured. Moreover the results of this experiment were abundantly confirmed by the fact that in some works at Lyons, destroyed by a fire which melted the engines, all the walls that had been constructed of gypsum remained intact, the same being the case at the burnt-down Théâtre des Celestius, Lyons. At the Health Exhibition Conference it was properly pointed out that in fire-resisting floors large iron girders, where necessary owing to the span, should be cased in, to shield them from the direct action of the fire. But a very necessary precaution is to leave the ends of the girders loose on their bearings and with a cavity at the back, because, though the fire does not directly attack the iron girders, it heats them, causing expansion and if bound at the ends they would thrust out the walls."

Experiments were made to determine whether tiles with cavities or hollows should run parallel or at right angles with the supporting joists, and it was found that the tiles with cavities at right angles to the supporting joists were nearly three times stronger than those with cavities parallel to the supporting joists. A test of the arches by heating, sudden cooling, and by dropping a heavy block of wood on them proved a like relative superiority.

Professor John Goodman, in a lecture given by him at the Yorkshire College, Leeds, on "Fire Prevention," stated that in his experience so far as concrete is concerned, there is no doubt that it is practically fire-proof; "but in conjunction with iron, as generally used, it is to be condemned, from the simple fact that iron, from want of proper protection, expands rapidly under the influence of heat, and consequently disturbs and breaks the rigid concrete, causing it to fall in large masses."

The cuts show the method of fire-proofing girders, columns and floors, and are self-explanatory. They show that lightness, strength, and ventilation are all provided for.

Machinery in Building.

THE remarkable extent to which machinery has superseded hand labor in modern times finds no exception in the art of building. In this art it has become a constant aid not only in the preparation of materials, but in the preparation of sites for building, and in the actual erection of structures stones are sawn and dressed by machinery. Bricks are made by machines. Machine-drilling for blasting has everywhere supplanted hand-drilling. Piles for foundations are driven by steam pile-drivers, and the prepared materials are hoisted by steam instead of being lifted by hand windlasses, or carried up tedious and wearying ladders on the backs or shoulders of men.

But it is in the preparation of timber, the dressing of lumber, and the manufacture of doors, sashes, window-casings, moldings, etc., that machinery has effected the greatest revolution in the art of building. Sixty years ago all, or nearly all, this work was done by carpenters with hand tools from lumber, which, except seasoning, was just as it came from the sawmill. Even

shingles were hand made. Now shingles, when used at all, are almost universally made by machinery. Flooring is supplied from the mills planed and matched, all ready for laying. Machine made doors, window-casings, door-casings, sashes, blinds, wainscoting, base-boards, and moldings, leave little for a carpenter to do to fit them to their places.

The Illustrated Carpenter and Builder (London, Oct. 5) discusses the proper machinery outfit for a general builder's business of moderate extent. The question of kinds and capacities is considered on the basis of forty men employed.

"The following engineering plants should meet the requirements, and be well and profitably employed: An engine of not less than 8 horse-power; a circular saw or joiner's bench, to carry a 36-inch circular saw, arranged with a rising and falling spindle and tenoning and boring apparatus; a vertical spindle molding and shaping machine; a hand-power mortising machine; and a mortar mill, with suitable shafting; in all of the value of about $2000. With this plant a very considerable amount of work can be turned out. If the engine is to be fixed permanently, the horizontal type, with a Cornish or Galloway boiler, is to be preferred; if it has to be moved from place to place the ordinary portable engine on wheels is the best form. In this latter case the engine should have light hoisting gear attached, as on a contract of moderate extent this will dispense with the services of several laborers. With the saw bench deals and boards up to 12-inch deep can be converted and cross cut for door stuff, etc.; and all kinds of flatting and deepening, plain or feather-edged boards, matched boards, skirtings, scantlings, etc., can be readily turned out. After the wood has been sawn, it can be tenoned, grooved, tongued, rebated, or bored, as desired, and without the aid of very skilful labor."

One of the most useful machines in a builder's business is a vertical spindle molding and shaping machine by which straight or curved moldings and circular headed or straight sashes may be worked. "On such a machine planing, thicknessing, rebating, shaping and stop-chamfering can be perfectly performed.

"Old pieces of wood may be converted into moldings or otherwise; door rails and similar light work may be planed or thicknessed. It will work as well in oak and hard woods as in pine or the softer woods. Gothic for church decorations, pew backs, and other moldings may be shaped and molded with facility; and if the cutter spindle is arranged to angle, difficult undercut moldings may be produced at an immense saving over hand labor. In fact, this machine properly constructed and worked may be pronounced one of the most valuable of all wood-working machines. The operations of the mortising machine and mortar mill are too well known to need notice."

In establishments, however, where machines for wood-working are used without system, much valuable time is lost. Tools are often out of order, which entails not only loss of time but inferior work. In such establishments machines fail to be so profitable as in other shops where order and system prevails. To be profitable each machine should be under the care of one man whose duty it is to keep it in perfect working order, and as far as possible to operate it himself when work requiring its use presents itself. Duplicate cutter-heads will aid in keeping the machines in order. The cutters should be of best quality. Great care in sharpening should be taken to preserve the profile of molding cutters.

It is estimated that an outlay of about $2000 would purchase such an outfit as described, and that, say in a job of building six ordinary houses it would, at a cost of about $60 per week, replace the services of fifteen men. It is also suggested that when an estate of some extent has to be built over, it would pay a builder well to hire or purchase a brick machine and make his own bricks. In selecting a brick machine, it is best to have sample bricks made by different machines out of samples of the clay intended to be used, which will help in determining which of those in market is best adapted to working that particular clay.

As to stone working, in the execution of

large contracts it might be also profitable for builders to use machinery for it. Portland, Bath, York, and all freestones and sandstones, can now be sawn, planed, or molded by machinery with facility, the work being so well done as not to require subsequent finishing. Even some of the limestones can be thus worked. Sills, heads, string-courses, steps and either plain or molded copings can be produced by machinery much cheaper than by hand labor. Even the harder stones used for flagging, etc., can be surfaced much more cheaply and accurately than by hand work.

Education of Building Trades Workmen.

THE address of Mr. E. W. Montford, president of the Architectural Association, as reported in *The Architect* (London, Nov. 2) contains remarks concerning the better education of workmen in the building trades which are of more than ordinary interest; and in general the address is somewhat above the usual standard of such discourses. Of the scheme for education of workmen originated by Mr. Owen Fleming, a hopeful view is taken.

"Our communications on the subject with the various city companies, the trades unions and other bodies have received general approval, and with your consent a preliminary conference will shortly be held, at which all the above mentioned bodies will be represented. When the subject was first broached the paper *London* was good enough to criticise our action with a good deal of disfavor, but as it was evident that it entirely misunderstood our intentions, no one troubled to reply. They seemed to think that it was an endeavor upon the part of architects, whom they were good enough to call a 'most notoriously ill-educated profession,' to patronize the workmen, and advised us to look to ourselves first. Well, no one can say that the Association has neglected the education of architects. That has been our great object for over fifty years, and for a good many years past we have been fairly successful. Our system is not yet perfect, and probably never will be, but it is as good as we know how to make it for the present, and we shall endeavor to improve it still more as time goes on. So having done our best for ourselves, we naturally desired to help the workmen with whose coöperation we are beautifying more or less, according to our abilities, the face of Great Britain. We have no desire to patronize them (why should we?), but merely to treat them as fellow-workmen with a common object. In helping them we are helping ourselves, for beautiful workmanship may go far to redeem a bad design, while a good design may suffer immensely from bad workmanship. The architect is the chief workman, but absolute success in any building can only be obtained by every workman of every trade employed upon it doing his very best, and uniting in a common effort to make the building in all its parts perfectly beautiful and perfectly strong. It is in this spirit that we are approaching the conference, and if, as I believe, the other workmen understand this, we may hope to produce some beneficial results."

INDEX TO LEADING ARTICLES.

The journals quoted are indicated by initials, and their full titles are given in the opening pages of the Review. Other abbreviations are, Ill=Illustrated; W=Words.

*26658. First Principles in Architecture.—The Coming Architect an Engineer. William H. Goodyear (E Mag-Jan.) 3000 w.

*26663. The Architecture of Municipal Buildings. E. C. Gardner (E Mag-Jan.) 3000 w.

*26712. The Reliance Building, Chicago. Ill. (E-Nov. 2.) 2700 w.

*26741. The Professional Side of Architecture. (Abstract.) E. W. Mountford, with Editorial (B A-Nov. 2.) 4000 w.

*26742. Improvements at the Houses of Parliament (B A-Nov. 2.) 1200 w.

*26758. Gypsum as a Fireproof Material. Ill. (I C B-Nov. 2) 900 w.

*26767. Decorative Circles. Ill. H. Leslie Ramsey (Pl D-Nov. 1.) 1500 w.

*26769. Wooden Architecture of Norway. Ill. (B-Nov. 3.) 2700 w.

†26781. Description of a Chatty Roof. Ill. D. Upson (I E-Oct. 6.) 500 w.

We supply copies of these articles. See introductory

*26836. The Granite City—Aberdeen. Ill. Arthur Lee (S-Nov.) 1400 w.

*26839. Wilhelm Lübke (A L-Nov. 2.) 2000 w

*26841. Presidential Address of E. W. Mountford (A L-Nov. 2.) 4200 w.

*26842. Stonehenge. (A L-Nov. 2.) 3600 w.

†26891. Emotional Architecture as Compared with Classical. Louis H. Sullivan (I A-Nov.) 6000 w.

†26892. Architectural Education. Henry Van Brunt (I A-Nov.) 2700 w.

26893. High Buildings and Good Architecture. Thomas Hastings (A A-Nov. 17.) 2000 w.

26894. Professional Ethics. John A. Fox (A A-Nov. 17) 1000 w.

26895. Notes on the Early Christian Monuments of Cornwall. Arthur G. Langdon (A A-Nov. 17.) 2700 w.

26902. Test of Terra-Cotta Floor Arches in Rochester, N. Y. Ill. (E R-Nov. 17.) 1000 w.

*26957. Address of F. C. Penrose before the Royal Institute of British Architects (B-Nov. 10.) 10000 w.

*26966. Bending Timber. J. C. B. (I C B-Nov. 9) 700 w.

*26970. Hammerbeam Roofs. Ill. (I C B-Nov. 9.) 1600 w.

27037. Evolution of American Architecture. J. W. Yost (A & B-Nov. 24.) 4500 w.

27057. The Vicar's Close at Wells. Ill. (A A-Nov 24.) 4400 w.

27068 Steel and Cast Iron in Buildings (I T R-Nov. 22) 700 w.

*27074. The Deposit of Priced Quantities. (Abstract.) John Holden (B A-Nov. 16.) 1400 w

*27078. Old and New Buildings in Edinburgh (I C B-Nov. 16.) 2200 w.

*27083. Convention vs. Invention (I C B-Nov. 16) 2000 w.

*27114. Strength of Arched Iron Ribs. Ill. (B-Nov. 17.) 600 w.

*27115. The Study of Modern Architecture. A Beresford Pite, with Discussion (B-Nov. 17.) 10500 w.

27141. The Reliance Building, Chicago. Ill. (Sc A S-Dec 1.) 2800 w.

†27234. Straightening a Leaning Chimney 100 Feet High. Ill. Joseph C. Platt (A S M E-Dec.) 1200 w.

27274. Modern Construction of Floors and Partitions in Commercial Stables. Ill. H. J. Campbell (E R-Dec. 1.) 2000 w.

27302. Modern Style Founded on Ancient Greek Architecture. Russell Sturgis (A & B-Dec. 1.) 3500 w.

*27303. The Endurance of Structural Metal Work. C. H. Blackall (B B-Nov.) 3000 w.

*27328. Architecture in Newcastle. (Abstract.) J. Oswald (B A-Nov. 23.) 1200 w.

*27351. The Architecture of China. Frederick M. Gratton, with Discussion (B-Nov. 24) 4500 w.

27360. Building Estimates. Charles C. Wilson (I-Dec. 1.) 2000 w.

*27368. Efflorescence on Walls (I C B-Nov. 23.) 600 w.

27397. Steel Foundations of Tall Office Buildings. Ill. (Sc A-Dec. 8.) 1100 w.

27399. The Plaster Center Piece Industry. Ill. (Sc A-Dec. 8) 800 w.

27418. Failure of a Building at Montreal, Canada (E N-Dec. 6.) 700 w.

Serials.

2285. Construction. M. Viollet-le-Duc (A A-Began Feb. 1892—25 parts to date—15 cts. each).

12568. Building Construction and Superintendence. F. E. Kidder (A & B-Began May 6, 1893—36 parts to date—15 cts. each).

19078. Problems in Stone Cutting. Ill. Ed. W. Hind (S-Began Jan.—9 parts to date—30 cts. each).

19218. Manhattan Life Insurance Building. Ill. (E R-Began Jan. 20—5 parts to date—15 cts. each).

19713. Brick and Marble in the Middle Ages. Ill. G. Edmund Street (B B-Began Jan.—11 parts to date—30 cts. each).

20419. Modern Methods of House Painting. A. Ashmun Kelly (Pl I)-Began March—9 parts to date—30 cts. each).

21736. The Art of Building Among the Romans. Ill. Auguste Choisy. Translated by Arthur J. Dillon (B B-Began April—7 parts to date—30 cts. each).

25177. Colonial Architecture in Western Massachusetts. Ill. George C. Gardner (A A-Began Sept. 15—2 parts to date—15 cts. each).

25943. The Pernicious Practice in Selecting Competitive Plans. A. Mc C. Nixon (S A-Began Oct.—Ended Nov.—2 parts—30 cts. each).

26069. Modern Steel Fireproof Construction. Ill. T. M. Small (A & B-Began Oct. 13—2 parts to date—15 cts. each).

26070. The Planning and Construction of American Theatres. William H. Birkmire (A & B-Began Oct. 13—2 parts to date—15 cts. each).

26135. Artificial Foliage in Architecture. Ill. Hugh Stannus (J S A-Began Oct. 12—5 parts to date—30 cts. each).

26838. Notes on the Great Railway Stations of London (A L-Began Nov. 2—1 part to date—30 cts).

26967. Stained Glass and Fret Lead Windows, etc. W. J. Eden Crane (I C B-Began Nov. 9—1 part to date—30 cts).

26971. An American Passenger Station—St. Louis (I C B-Began Nov 9—Ended Nov. 16—2 parts—30 cts each).

27036. The Basilica and Its Adaptation to Modern City Churches. Ill. George Ashdown Audsley (A & B-Began Nov. 24—1 part to date—15 cts).

27297. Strains in Compound Framed Structures. Francis Schumann (A A-Began Dec. 1—1 part to date—15 cts).

27369 Foundations in Deep and Unreliable Soils. J. Nelson (I C B-Began Nov. 23—1 part to date—30 cts).

CIVIL ENGINEERING

For additional Civil Engineering, see "Railroading" and "Municipal Engineering."

Maximum Practical Length for Suspension Bridges.

A FIRST installment of the report of the board of officers of the Corps of Engineers, U. S. A., directed by the Secretary of War to investigate certain bridges with a view to place in the possession of the department such information as is needed for the proper determination of questions relating to erection of bridges over navigable streams, is printed in *Engineering News* (Nov. 22). That journal justly pronounces the report "one of the most interesting and instructive of engineering documents." In its preparation most of the famous bridges in the world have been considered with reference to features applicable to special conditions that must be considered in the construction of particular bridges.

So many topics have thus been treated, that our purpose will be best subserved by selecting one of the most important as a sample of the thoroughness with which the ground has been gone over. Without doubt the topic of prime importance, as related to the question of practicable spans, is the strength of materials; though loads, foundation, wind pressure, oscillation and bracing, each formed a subject of special investigation, as directed by Gen. Casey, Chief of Engineers, to whom the report is made.

"The wire employed in the cables of the New York and Brooklyn bridge (the largest cables yet made) had a tensile strength of 170,000 pounds per square inch, and the cables were originally designed to contain each 6188 wires of No. 7 B. W. G.; but as some heavier wires were introduced during construction, the actual number of wires was only 5400." These cables have a diameter of 15.578 inches. The cables of the Cincinnati suspension bridge are 12 inches in diameter and contain each 5200 wires.

In the construction of the New York and Brooklyn bridge cables it is believed the practical limit of the number of wires that can be used in a cable was very nearly attained. This limit is imposed by the impossibility of securing in a materially larger number of wires an equal tension for each of the wires in the cable. The tensile strength of wire at present obtainable within feasible limits of cost is 180,000 pounds per square inch.

"The total cable strength available for the support of the bridge depends upon the number of cables which can be practically combined as a single cable system on one side of the bridge. If many cables are employed it becomes difficult to distribute the strains among them so that each shall carry its proportionate load under the varying conditions of temperature and traffic. It is not easy to decide what is the practical limit of the number of cables to be assembled together. Where parallel wire cables are used, they must be sufficiently separated horizontally and vertically to give room for the operation of the wire wrapping machine, and this requires intervals of at least 3 feet during construction."

Multiplying the number of cables introduces another set of difficulties. If a lateral arrangement of the cables on the saddles be adopted, "the cradling of the cables in converging planes (which is desirable for lateral stability) requires considerable intervals between the saddles." If the cables are arranged in one or more vertical planes, they must be "held the same distance apart throughout their length by suspender clamps, in which case the saddles on the towers would be closer together. Still the number of cables suspended on each side cannot be made very large without increasing the dimensions of the towers and the piers supporting them far beyond the requirements of the roadway and the suspended loads."

A vertical arrangement of the cables (or

a combination of vertical arrangements) is regarded as presenting special advantages, requiring less width at the top of the towers, and affording opportunity to stiffen the bridge by a system of trusses.

"Whatever arrangement is adopted, the Board are of the opinion that it would not be found convenient to work more than eight cables together as one cable system. For the purpose of this investigation it is therefore assumed that the suspension bridge of maximum span is supported by 16 21½-inch cables."

In the course of the argument a comparison is made of the strength of wire cables, as compared with chains, and the superiority of the former is indicated. "Steel in the form of wire has a minimum strength more than double its maximum strength in the form of bars suitable for the construction of a suspension chain. A link chain will therefore weigh about 2½ times as much as a wire cable of equal carrying capacity."

The first installment of the report covers the topics of strength of materials, loads, oscillations, including wind pressures, from which in suspension bridges oscillations are set up, and the final answer to the question of maximum span is deferred till other topics bearing upon it are discussed. These, having been exhaustively considered in installments printed Nov. 29th and Dec. 6th, supply accurate data for use in the formulæ employed in an elaborate mathematical computation, which gives the result of 4335 feet as the maximum span of a suspension bridge.

The Canal Des Deux Mers.

ON the map herewith presented the present marine route from the English Channel skirting the Bay of Biscay and the coast of Spain, and thence through the Mediterranean sea, to the Suez canal, is shown by a full line, and the shorter route via the proposed ship-canal "Des Deux Mers" is indicated by dotted line. It will be seen that the distance via the canal, indicated by the heavy black line, is not very much more than one-third that of the present route.

The line of the canal itself cuts across the neck of land which joins the great Spanish peninsula to the main land, and connects Bordeaux and Narbonne.

This map, and particulars relating to the projected canal are given in the *Engineer* (London, Nov. 9), which regards the project as impracticable. However it has been vigorously urged upon the French government, the pressure having at last become so great that a third commission has been appointed to examine the scheme and report upon its feasibility.

The project has for a long time been favored, particularly in the south of France, for the following reasons. Were a ship-canal constructed on the line proposed, vessels could pass freely between the northern Atlantic and the Mediterranean without going around Spain; the French naval squadron could be united without passing under British guns at Gibraltar, and as this is regarded as being a blow at English marine supremacy that would go far

Line of the French Canal des deux Mers

toward wresting from her the title of "Mistress of the Sea," Frenchmen are strongly influenced by such a consideration. Doubtless, also, were the canal to be constructed, certain commercial advantages would accrue to districts near it; and taking these considerations all together, the fascination with which the proposal is regarded by the French people is easily accounted for.

There is now the Languedoc canal connecting the Bay of Biscay with the Gulf of Lyons by which barges drawing 4½ feet of water can pass, and this fact is used as an argument for the practicability of a ship-canal. The traffic of the Languedoc canal, however is not important.

"Its construction, considering the time

when the works were carried out, constitutes one of the most remarkable engineering feats that have ever been accomplished. The scheme for constructing this canal was originated by Pierre Paul Riquet, who at the time he took up the project was a tax gatherer in the employ of the government, and the possessor of a small property in the neighborhood. Though by occupation only an exciseman, he taught himself sufficient mathematics, leveling, and surveying to enable him to lay out the line of the proposed canal, and of practical engineering to enable him afterwards to carry out the work. Having traversed the line of the canal several times on foot, examined all the sources of water supply; and had models made of the proposed locks and other works, in the year 1662, about a hundred years before Brindley began the Bridgewater canal, he laid the plans before Colbert, the controller-general of France, who was then actively engaged in endeavoring to open up new sources of wealth for his country. By order of King Louis XIV a commission was appointed to inquire into the scheme. After two months' investigation the commissioners reported it as practicable and a concession was given to Riquet to carry out the works. For the purpose of raising the money Riquet was granted the sole farming of the taxes in the provinces through which the canal would pass. This source of money however, proved utterly inadequate, and the scheme was hampered throughout the whole period of its construction by want of funds. However, Riquet with indomitable perseverance, overcame this and the other difficulties with which he had to contend, and the canal, which was commenced in 1666, was, after fifteen years labor, opened in 1681, six months after Riquet's death, and after the loss of all his property."

In 1880, a project for constructing a ship-canal with termini at Bordeaux and Narbonne, was brought forward. This scheme comprised a summit level of 525 feet, and sixty-one locks. Its estimated cost was above $106,000,000. A commission appointed, reviewing this estimate, reported it as much too small; the board of admiralty viewed the matter adversely on account of the difficulties of navigation and risks of accident, and a separate commission, considering the financial prospects as a question apart from the others, regarded them as hopeless. Thus the project was negatived on all sides, but it appears not to have been abandoned. In 1884, in a modified form, it was again pressed forward, only to be again examined by a government commission, and to be again adversely reported upon. But this has not deterred further efforts. The scheme is now again revived, and a new commission has been appointed to give it a third consideration.

The Engineer thinks "that after the reports which have been issued by previous commissions" it will be "a mere waste of time and money to make further investigations," and that, although the engineering features present no insuperable difficulties, yet, on the face of it, the scheme must be considered as financially impracticable." Criticisms of the features of the work, as now projected, include, among other things, an assertion that the sectional area of the canal is too small in proportion to the midship section of a large steamer, to allow passage except at a very low rate of speed.

Landslides.

OF landslides, one of the worst difficulties encountered in railroad engineering, Mr. David Molitor gave the results of what seems to have been a very exhaustive study, in a paper read before the Association of Engineering Societies and printed in *The Railway Review* Nov. 24. The paper was accompanied with numerous illustrations of typical landslides as they occur with different materials, and contains a thorough analysis of the conditions which in the different materials produce the sliding. In dealing with this part of the subject a good classification of landslides is made, which arranges them in four groups. "A. Those occurring where the slope is too steep to maintain equilibrium of the mass. B. Those caused by inclination of the natural strata, combined with the lubricating action of water.

In this and in the previous case we find a clearly defined sliding surface. C. Slides caused by the action of water alone. Here the material is softened to such a degree that it becomes fluid. D. Where the underground is not capable of supporting the weight of the overlying fill material."

The best means of prevention are discussed in due order with the different groups; but it is avowedly the author's main purpose to lead up "to a new method of finding the earth pressure . . . . as a step in advance of what has been previously done toward getting at the bottom of this matter. It is vain to expect to arrive at such results when dealing with such material as earth. The best we can ever hope to do is to approximate to the truth. It is also useless to experiment with dry earth, for nowhere in nature do we find large masses of earth in a dry state. An embankment constructed from absolutely dry sand would in a short time absorb moisture, and thereby assume entirely different properties. Of all experiments made, or to be made, those only are valuable which are made under the actual conditions existing in nature, and of these we will find the extreme cases most valuable. All engineering structures should be so designed as to comply with the most unfavorable conditions which may at any time occur, and this in itself is sufficient reason why experiments and investigations should be made under corresponding circumstances."

Some examples of landslides occurring with Opalinus and Turneri clays on a German government railroad in a portion whose construction was under his charge, are cited by Mr. Molitor. These clays "disintegrate into a fine powder which, when wet, presents all possible properties objectionable to the engineer." But these landslides were made serviceable in securing experimental data, being taken advantage of for this purpose as experiments on a large scale with special materials.

"Whenever a slide occurred, accurate cross-sections were taken and plotted on the original sections taken for the project. The general method of repairing these slides consisted in cutting vertical passages into the sliding slopes and filling them with rip-rap. In the course of such repairs the sliding surface, or surface of rupture, became exposed, and could be plotted on the corresponding cross-sections previously taken, thereby making a complete record of all the conditions attending the slide. The slides which are here referred to, and which prompted the following conclusions, were all caused by depositing material at a steeper slope than it could maintain.

"Numerous slides occurred also in the cuts through these clays, and although the slopes of such cuts were quite stable at first, yet it was easy to see that at some future time, when the material disentegrated, it would act precisely as it did in fills. It would follow directly from this fact that the slides which occurred in cuts would not present the same features as those in filled earth; and in making experiments we must remember that filled earth exerts the maximum pressure, whereas the very same material, in natural strata, may, after cutting, at first exert no pressure at all." This is explained by the fact that the material, in its natural layers, is more compressed or compacted than it will ever be after it has been dug up and moved about.

As the result of observations on these landslides, the following propositions are made in conclusion. "1. That what is commonly known as the angle of repose of a certain material, is not a constant angle but a variable, depending upon the vertical height of the slope. 2. That what is called the plane of rupture, is not a plane but a curved surface whose cross-section closely approaches the form of a hyperbola. 3. That the surface of repose, as would follow from proposition 1, is not a plane, but a curve. For practical purposes, however, we may use an average straight line for the slope.

"These three propositions, although they were determined only from experiments on Opalinus and Turneri clays, seem to be true for all materials, except that the relation of the height of slope to the angle of repose, and of the degree of curvature to the surface of rupture, vary

for different materials. It may be that the angle of repose varies less rapidly for sand than for clay, but we have no experiments on large sand embankments to verify this supposition. It is also possible that, for sandy material, the surface of rupture approaches more nearly to a plane, but all known experiments have been made on so small a scale that the conclusions become erroneous when applied to large masses."

Effects of Stress on Corrosion of Metals.

EXPERIMENTAL investigations upon the general subject of corrosion of metals have been much needed. The phenomena of corrosion have not been studied with that thoroughness which their importance demands. Mr. Thomas Andrews, however, presented before the Institution of Civil Engineers, at a recent meeting of that body, a series of researches which ought to set the pace for a complete elucidation of the causes which effect the chemical destruction of metals as used in modern structures, and the influences that act to retard or accelerate this action.

One of the lines on which Mr. Andrews has extended his investigations is the influence of stress upon corrosion; and contrary to what would probably be the general opinion in advance of experiment, this is found to retard rather than hasten the result.

The iron and steel upon which experiments were made were selected from standard samples. *Engineering News* (Nov. 15), has given a good account of the method employed.

"The specimens tested were large, rolled, wrought iron bars; wrought iron, hammered shafts; Bessemer and open-hearth forged, steel shafts and large bars of soft and hard Bessemer steel, soft and hard cast steel and aluminum, nickel, chromium, silicon and copper steel. Experiments were also made on rolled plates of wrought iron, Bessemer and open-hearth steel, and soft cast steel. The chemical composition and general physical properties of these specimen metals are fully set forth in tabular form in the original paper.

"The author estimated the relative corrosion of the 'strained' and 'unstrained' portions of the same metals by the galvanic method which he introduced some years ago with satisfactory results in his previous researches on the corrosion of metals. By means of the exceedingly sensitive galvanometer the slightest variation in the relative rate of corrosion between any two metals, immersed in an electrolyte, can be ascertained. In observing the influence of tensile stress upon the corrosibility of iron and steel bars, the following method was pursued:

"From each metal under investigation a bar was cut and turned into a test piece 6 inches long, 3 inches between heads, ¾ inch in diameter for this 3 inches and 1 inch and 1½ inches in diameter for the heads, each ¾ inch long. This bar was then submitted to a stress usually sufficient to produce an elongation of 20 per cent. between gage points 3 inches apart. After being strained, the piece was cut in two at the center, and both halves were turned down to exactly the same dimensions. In one piece the 'strained' end coincided with the middle of the test bar, and was left untouched in the lathe up to the point where there was any reduction in diameter, caused by the tensile stress. In the second half, the end corresponding to the 'strained' end of the first half was turned out of the head of the test bar, and this end thus consisted of 'unstrained' metal, or at least of metal considerably less under the influence of stress than the end of the first half.

"These two halves exactly alike in form, were then immersed, as a galvanic couple, in a saturated solution of sodium chloride, and sometimes in sea water. They were held in position in the beaker by insertion through two holes in a plate of thick glass, with the tapered ends only immersed to a depth of about ¾ inch in the solution. Galvanic contact between the two pieces of metal was only made momentarily at the time of reading the galvanometer, and the differences of potential between the 'strained' and 'unstrained' metals were thus observed. The terminals of the bars were connected with a delicate galvanometer, placed in a circuit, with results fully

tabulated in the paper of Mr. Andrews for each set of experiments. A sensible current was observed between the two bars, and the 'unstrained' end was found to be in the electro-positive, answering to the zinc in a galvanic couple. This indicated that the 'unstrained' metal was being more rapidly acted upon by the solution, and was thus corroding more rapidly than the 'strained' metal."

The conclusions reached are, that steel corrodes more rapidly than iron when exposed to sea water; that corrosion increases in such exposure as the per centage of carbon increases, that galvanic action as set up between iron and steel greatly promotes corrosion, and that stress acts to resist corrosion, all of which are important contributions to, or confirmations of, previous knowledge of this class of phenomena.

Solid Metal Bridge Flooring.

THE subject of solid metal bridge flooring is just now, and is destined to be in the future, one which bridge constructors must consider with a view to the selection of best types of construction, cost of erection, etc., since such flooring is now, and will continue to be, demanded for bridges crossing over streets in cities. Those desiring to get abreast with current opinion regarding the various types of solid metal flooring in use or proposed can find a good exposition of the requirements in a paper by Geo. B. Francis, M. Am. Soc. C. E., in *Engineering News* (Nov. 15).

"Three matters of prime importance in connection with bridge floors are being brought to the front very rapidly, and engineers will be obliged to give serious attention to them whether they wish to or not. 1. City ordinances and court decrees are going to specify 'solid metal, water-tight, ballast floors,' wherever tracks are to be carried over busy, city or village streets. Solid metal, because timber is inefficient; water-tight, because of the drip nuisance, and ballast floors to reduce noise to a minimum. 2. Such a provision is incomplete without a carefully-devised system of drainage gutters and conductors. 3. Such a solid floor must be selected as will suit the individual case to be met."

A bridge floor on Archer ave. Subway, Chicago, Ill., described and illustrated in *Engineering News* (Oct. 11), which is on a through girder bridge having floor troughs with four continuous joints in the bottom of each, is cited as a "typical example" of such a bridge, in which "the question of ballasts, style of floor and drainage have all received consideration," the result being "a finished design, whatever may be said of the final settlement of each question." Such a floor "is all right, provided an engineer can satisfy himself that the four continuous joints . . . to which water has access, are going to prove water-tight after some time in service, or after the expense of calking or other treatment to make them so has been borne."

This kind of flooring would not answer for a deck-girder bridge, being only adapted "for a floor that is hung in some manner; and for deck flooring a shape with flat tops and bottoms and inclined sides would be more suitable." A reason for regarding this form as more suitable, is the tendency for a rectangular shape to deform under load, whereas the "flooring with inclined sides" is free from this defect.

"It is also perfectly feasible to use the latter flooring where the bridge must be made with through girders, either by resting the flooring directly on the bottom flange of the girder or by cutting short the bottom member and resting the flooring on clips or shelf angles under the top member."

In such a construction proper provision for drainage must be provided, a suggestion for which is a drainage hole "punched in the shapes to take the water clear of the flange.

"It would seem that a floor with the bottom member made up in one piece, trough shape, would be more liable to give satisfaction for conveying water than one which has joints in the base, or which allows a ballast load in the trough to pull on the rivet heads, to say nothing of a saving in bottom flange metal and general economy due to sloping sides. It cannot be denied, however, that floors of excessive depth, say about 16 inches, suitable for

double track width, can be better made up of vertical webs; but it is questionable if excessively deep floors are desirable.

With reference to noise, the pavement under the bridge is a potent factor, and to get good results something like asphalt is required, a material that will make a comparatively noiseless pavement.

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The journals quoted are indicated by initials, and their full titles are given in the opening pages of the Review. Other abbreviations are, Ill=Illustrated; W=Words.

Bridges.

26865. Experience with Solid Metal Bridge Floorings. George B. Francis (E N-Nov. 15.) 1300 w.

26871. A Novel Detail for Suspension Bridge Cables. Ill. (E N-Nov. 15.) 1900 w.

26929. Mussy Viaduct—Paris, Lyons and Mediterranean Railway. Ill. (R R-Nov. 17.) 900 w.

*27344. Ruthven Bridge, Kingussie. Ill. (I & I-Nov. 23) 900 w.

27398. The Roman Bridge in Mostar. Ill. Sc A-Dec. 8) 400 w.

Canals, Rivers and Harbors

*26657. The Drainage System of the Valley of Mexico. A Vast Engineering Accomplishment. M. Romero (E Mag-Jan.) 4000 w.

*26700. Canal Traffic in France (C G-Nov. 2.) 3000 w.

26823. The Proposed Deep Waterway from the Great Lakes to the Ocean. Wendell L. Simpson (Sc A S-Nov. 17.) 4000 w.

†26843. The Rivers of Central Asia. Ill. E. A. S. (I E-Oct. 13.) 2200 w.

26856. From Lake to Gulf. Douglas Wolworth (T-Nov. 15.) 1800 w.

26864. Earth Excavation in Section I and K, Chicago Drainage Canal. Ill. (E N-Nov. 15.) 1500 w.

*26952. The French Canal des Deux Mers (Eng L-Nov. 9.) 2300 w.

*27014. French Canals and Canal Traffic (Tr-Nov. 9.) 3600 w.

27019. The Construction of a Concrete Wharf at Portslade. Ill. Joseph Cash (E N-Nov. 22.) 600 w.

27140. The Locks at the Ends of the Canal Between the North and Baltic Seas. Ill. (Sc A-Dec. 1.) 700 w.

*27244. Great Canals. A. G. Menocal (Ch-Dec.) 4000 w.

*27379. The Inclined Planes of the Morris Canal. Ill. (A E R J-Dec.) 2500 w.

27422. Nicaragua Ship Canal. Ill. Alex. D. Anderson (M R-Dec. 7.) 1000 w.

Hydraulics.

*26733. Hydraulic Capstans. Ill. Arthur Rigg (P Eng-Nov. 2.) 2500 w.

26869. Diagram for Discharge of 2 to 7 ft. Brick Conduits Flowing Full. F. S. Bailey (E N-Nov. 15.) 350 w.

*27260. On the Utilization of Water for Power and Transmission of Same. John Ritchie (C G-Nov. 23.) 5000 w.

27359. The Capture of Niagara. Ill. (From McClure's Magazine) (T-Dec. 1.) 3000 w.

Irrigation.

*27269. The Utilization of the Nile. Editorial (Eng L-Nov. 23.) 1200 w.

*27372. Egypt and the Nile. (Abstract.) Colin Scott Moncrieff (I C B-Nov. 23.) 3000 w.

Miscellany.

26899. Repair of the Moline Wall. Ill. Charles Francis (E R-Nov. 17.) 1100 w.

26918. The Effect of Stress on the Corrosion of Metals. (Abstract.) Thomas Andrews (E N-Nov. 15.) 1400 w.

*27050. On Waterworks Construction and the Use of Concrete and Earthwork in Forming Embankments. William Watts (C G-Nov. 16.) 4000 w.

27135. Landslides. Ill. David Molitor (R R-Nov. 24.) 4000 w.

†27233. Some Tests of the Strength of Spruce Columns. Gaetano Lanza and Edward F. Miller (A S M E-Dec) 500 w.

27413. Enlarging a Tunnel in Soft Ground. Ill. (E N-Dec. 6.) 900 w.

Serials.

22670. The Iron Gates of the Danube. Bela von Gonda (Eng L-Began June 1—4 parts to date—30 cts. each).

25858. The North River Bridge—Appendices (E R-Began Oct. 13—5 parts to date—15 cts. each).

26048. West India Dock Improvement Works. Ill. (E-Began Oct. 12—Ended Nov. 9—3 parts—30 cts. each).

26914. Waterways vs. Railways—Deep Water Routes to Connect the Great Lakes and Rivers with the Ocean (R A-Began Nov. 16—3 parts to date—15 cts. each).

26998. The Chicago Drainage Canal. Ill. (E-Began Nov. 9—Ended Nov. 16—2 parts—30 cts. each).

27020. The Maximum Practicable Length for Suspension Bridges (E N-Began Nov. 22—Ended Dec. 6—3 parts—15 cts. each).

27032. Sundry Engineering Matters Considered in the Construction and Operation of the New York and Brooklyn Bridge. Ill. (R G-Began Nov. 23—Ended Dec. 7—3 parts—15 cts. each).

27071. Graphic Method of Taking Out Areas, Banks and Cuttings. Ill. R. E. (I E-Began Oct. 27—1 part to date—45 cts).

DOMESTIC ENGINEERING

Bacteriology of Sewer Air.

WHILE it is most generally admitted that disease germs are transmitted by sewers, there has been much difference of opinion relative to the precise manner in which diseases—typhoid fever, for example—are conveyed from one point to another at a considerable distance. The difficulty in fixing upon a precise way in which these germs gain access from sewers to the atmosphere in inhabited dwellings, has led to some skepticism that this actually takes place, as believed by most sanitary authorities. The question may perhaps be regarded as still unsettled; but experimental research, the only way in which a solution of it can ever be reached, is in active progress.

Among the most notable of these researches are those conducted by David Arthur, M. D., Demonstrator, Laboratory of State Medicine, King's College, London, the results of which were communicated to the recent Sanitary Congress, and were printed in the *Sanitary Record* (Nov. 10, 1894).

The researches of Dr Arthur were directed to sewer air at the ventilators, for the reason that sewer air existing midway between two ventilators, which is the air hitherto principally examined, contains, "roughly speaking, only half the number of micro-organisms that are found in the external air at the same time." From this fact observers have argued that the micro-organisms must have come from outside air; that the damp walls of the sewer would act like a Hess's tube, and so account for their diminished number. "No doubt such is the case; but being, however placed in such a moist trap as a sewer, it is a matter worthy of consideration how it comes about that the sewer air contains even so many micro-organisms, when it is taken into consideration that the air gently drawn through a common Hess's tube is sterile. This can be best explained after noting the condition of sewer air at the ventilators." Dr. Arthur claims that his observations are the first that compare the bacteriology of ventilating air of sewers and outside air.

"Here invariably, when the ventilator was acting as an outlet, I found more micro-organisms in the exit ventilating air than in the sewer air, and if there had been rain recently, many more even than in the outside air; and vice versa, if the ventilator was acting as an inlet. I invariably found more micro-organisms at the bottom of the ventilator than were present in the outside air.

"This increase of micro-organism was the first means of making me suspicious of the deductions of past observers, and made me incline to believe that, after all, the sewer *did* give off micro-organisms. Naegel asserts that 'slight upward air currents are enough to prevent floating bacteria from settling down. The condensed watery vapor that surrounds them tends to maintain their buoyancy.' So the constant deposition that takes place in a horizontal sewer will be stopped when it reaches the exit ventilator, and at the exit will be found the number of micro-organisms present in the air, plus what was given off from the ventilator wells. But in the sewer itself there would be no increased collection, as the micro-organisms would be deposited in the same section of the sewer where they were given off.

"With this theory, then, there is a continual deposition and a continual elimination of micro-organisms, the balance being the number found. This theory accounts for the small number found in sewers and the greater number found in outlet ventilators; not only so, but makes it clear how past observers could not in many cases explain their results."

To test whether and how micro-organisms were given off from sewers, he performed the following experiments, based upon the proposition that "micro-organisms are being continually deposited and continually given off."

"A large tube, 5 feet 5 inches long and 2¾-inch bore, was plugged at one end and partly filled with water, and gently rotated in the horizontal position. A Frankland's tube was put through the gutta-percha stopper, and 15 liters of air aspirated. This air was found to be practically sterile. The tap water was run out, and fresh sewage substituted for it. Still the 15 liters of air that were aspirated from over the fresh sewage were practically sterile.

"Now the micro-organisms and molds collected from about twenty sewer-air experiments were placed in the tube along with a little sewage ¾inch. Four days later, when there was a liberal growth of molds, 15 liters of air were aspirated from the surface of the molds and sewage, when there was found a large number of micro-organisms. This experiment was confirmed several times, both with Frankland's method and with Sedgwick and Tucker's tube. Again, I confirmed these experiments in another method, by aspirating air through sewage.

"It was found that by aspirating 10 liters with gentle bubbling, 3 organisms were found; 10 liters with violent bubbling, 6 organisms were found; 11 liters over fresh sewage, 3 organisms were found; 10 liters over broken dried sewage, innumerable.

"Again, I had two flasks one-third full of broth-culture connected by a brass tube about quarter-inch bore. This tube had a siphon bend upon the portion between the flasks and each end of the tube dipped beneath the surface of the broth. Into each flask there was put a bent air-pipe, plugged at the external end with cotton wadding. All the joints were covered with beeswax and vaseline. The contents of the flask were sterilized by boiling for five minutes during three consecutive days. The trap connecting tube was coated with organic matter by pouring the broth from one flask to the other. After the contents of the flask were cool, and the trap full of the nutrient broth, one flask was inoculated with typhoid bacilli, and the whole placed in the incubator.

"In three days the contents of the inoculated flask were cloudy. After twenty-one days the fluid in the trap became cloudy, and seven days later the fluid in the second flask also became cloudy. Drop and cover glass preparations were made from the latter, when the typhoid bacillus was found in abundance.

"This in my opinion is one of the principal ways sewage microbes find access to sewer air. The bacteria of the sewage may creep like those of typhoid up the walls of the damp nutrient sewers, so that they may be literally alive with them. Molds here also grow with great proliferation. In their struggle for existence they will often be covered with bacteria, and in shooting forth their spore stalks must carry some bacteria out with them. When the spore heads are sufficiently long to project from the damp sewer walls, and have become ripe for dissemination the clinging bacteria and their spores will become liberated mold-spores, and bacteria, or their spores, will be wafted with every air current; many will gravitate to the sewage; others will stick to the damp sewer walls; others will be carried up the ventilators to the outside air; while others, again, may gain access to dwelling houses."

Confirmatory opinions of a number of scientific authorities are quoted to support these views; and these also sustain the opinion that sewer air in contact with such infected material becomes imbued with specifically contagious properties. As to the identity of these organisms respectively isolated from external air and from sewer air as alleged by previous eminent investigators, the experiments of Dr. Arthur afford a striking confirmation.

Transplanting Trees.

A VERY important part of arboriculture is the transplantation of trees. Many things are necessary to be observed in order that this operation may be successful, even for small trees, and this is all the more true, when adult trees are to be transplanted, as is frequently done for adornment of parks and ornamental grounds. With reference to transplanting deciduous trees after the 1st November in the latitude of New York, an answer is

given to inquirers in *Garden and Forest* (Oct. 31). It is not enough that a tree shall have vitality left to put forth its leaves after transplanting. Nothing less than "an unshattered constitution, a vigorous life, a promise of longevity, and conditions which insure its best development in size, beauty and in characteristic expression" will satisfy an enterprising planter.

"Small trees can be moved successfully at any time of year by one who knows just how to do it. But in this latitude the transplanting of trees ought not to be postponed until as late as the middle of November. Certainly, no tree ought to be transplanted after this date unless the ground has been thoroughly and intelligently prepared beforehand. If trees must be dug or purchased now, it is better to heel them carefully and at once begin to prepare the place where they are to live permanently.

"We have often explained why a large pit should be excavated for a tree. A wholesome tree needs a great deal of food, and it must stand in a soil whose texture will make that food available. Where trees are to be planted in groups the whole ground should be trenched to a depth of two feet, and for a single long-lived tree an excavation which is ten or fifteen feet across and three feet in depth is none too spacious. The surface-soil should be placed to one side and the stones removed from the hardpan. This subsoil should be returned to the pit, and it will be all the better if a little rich soil and peat can be mixed with it, and then the surface-soil should be placed on the top as before. During the winter all this will settle and become firm, while the action of the frost will reduce the size of the particles. Next spring the trees can be lifted and placed in a small hole made in the center of the large one, care being taken as the roots are covered to ram the ground tightly about them. If we wait till spring to dig these holes, or if the tree is planted in them now when they are freshly dug, the soil will settle away from the roots as the tree sways in the wind, or the rain will wash it away, leaving air-spaces about the roots, which are fatal to the tender feeding fibers already formed, and which offer no encouragement for others to take their places. If the trees are properly heeled in a sheltered place to prevent evaporation, a sufficient number of roots will form to keep the branches plump during the winter; the scars, where bruised roots have been cut away, will have become calloused over, and they will suffer no shock when removed to their abiding place in spring, but will continue to grow as if they never had been disturbed. If trees are to be brought from a distance it is, therefore, better to procure them in the autumn than to wait until spring, and everything will be at hand for prompt action at a time when work of many kinds is pressing. If it is too late to secure the trees in time to heel them in while the ground is still warm and open, they should be procured at once and wintered in a cellar or pit. If they are heeled in they should be placed in a rather shallow trench and in an inclined position, and far enough apart to allow fine soil to penetrate every portion of the space occupied by the roots without leaving any unfilled interstices. The ground of course should be dry and well drained; no stones, clods or sods should be used in the filling, nothing but finely pulverized soil. A portion of the stems, as well as the roots, should be buried and the surface rounded, and it is better to dig a trench around the whole area occupied by the tree-roots, because mice will not be liable to push up under the snow against an inclined bank of earth."

An argument is made for the strict observance of the method described, and the rationale of the directions is discussed. That these directions are not generally well known, and where known are not sufficiently heeded, is regarded as accounting for the frequently unthrifty condition and numerous failures of transplanted trees. Unless a tree "be fed and made happy in its new surroundings, as systematically and judiciously as if it were a growing animal, the result will be a lasting disappointment and regret." No part of the art of landscape gardening requires greater care and attention to details than transplanting trees.

Climbing Plants on Boston Buildings.

THE use of climbing plants in mitigation of bad architecture, as exemplified in Boston, is made the subject of an interesting article in *Garden and Forest* for November. "Probably nowhere else in this country does the service performed by climbing and clinging plants in clothing and adorning the walls of buildings receive such good illustration as in and around Boston. Ampelopis tricuspidata was first domesticated here, and has so long been a striking feature of this city as to gain for it throughout the country the familiar name of "Boston Ivy." This name, however, is seldom heard here, where it is most commonly known as the "Japanese Ivy" or the "Japanese Ampelopis."

The Museum of Fine Arts in Boston is cited as a remarkable example of the effect of this creeper in concealing architectural defects. "It clambered bravely over the ugly walls of the parti-colored terra cotta and brick, and for awhile so nearly effaced the unspeakable reliefs of the second story as to give them the charm of indefiniteness. But the trustees have since restricted the creeper to the first story."

Another conspicuous example out of many which are cited is the "Old South Meeting House, where it creeps over an enormous expanse of gray old walls and high up on the tower, relieving the severity of the Puritan architecture." The old gateway of the Granary burying ground, adorned by this creeper, has been spoken of as one of "the most beautiful things in all Boston." Of the value of trailing growths for fences in parks and grounds there cannot be two opposite opinions, but it is not fully appreciated.

"In Germany the Virginia Creeper is put to simple and effective use for this purpose in urban public grounds. A light low fence is made of stakes and connecting wires; the Virginia Creeper is trained up each stake and made to form graceful festoons between. Its employment in some fashion would do good service on a place like the Cambridge common, for instance, now a bare, unattractive expanse, having a sort of kinship with the New England rustic burying-ground. It is surrounded by a fence composed of unhewn granite posts with squared rails of wood between. Virginia Creeper, Japanese Ampelopis, and perhaps other twining or climbing plants, might convert this old fence into a thing of beauty. In public parks the requirements for protection of the borders sometimes necessitates guards of wire and stakes along the paths. These are often great disfigurements, and their offensive aspect, in places where they seem to be required permanently, might be at least mitigated by the use of Virginia Creeper after the German fashion."

Another climbing plant said to be "coming into marked favor is the Evonymus radicans, from Japan." English ivy is not thoroughly hardy in and around Boston, though considerably used.

Combination Heating.

MR. GEO. HOFFMAN writing upon this subject in the *National Builder*, regards the system of heating by the use of hot water or steam, and heated air as "here to stay," and enumerates certain advantages claimed for this method. Perhaps for the general reader, it may be well to say that in this system, air brought in fresh from the outside of a dwelling through pipes or ducts (usually called in heating specifications the "cold air boxes") is heated by a furnace in the usual manner, and is conveyed through warm air pipes to parts of the building where it may be circulated with ease and certainty; while parts so located that it is difficult to get the warmed air to them by simple flow through pipes are warmed by steam or hot water. The steam or water for this purpose is usually heated by the same furnace, which is specially constructed with a heating coil or a steam generator for this purpose. In warming larger buildings, used as schools, etc., a separate furnace for heating air, and a boiler for supplying radiators with hot water or steam are sometimes used, but this would not, strictly speaking, be known in the heating business as a combination system, the term being confined to systems wherein the same heating furnace supplies

heat to different vehicles for conveying warmth to the apartments to be heated.

"Air will absorb heat much more rapidly than either liquids or solids and as in combination heating we are depending for fully fifty per cent. of our warmth on air-heat, the natural conclusion is that a combination heater will give results in the rooms to be heated much quicker" than either steam or hot water used singly. Of course it will be understood that very good ventilation may be attained in this way by a well constructed apparatus.

American Society of Heating and Ventilating Engineers.

MANY suggestions for the Advancement of this new association are contained in *Heating and Ventilation* for November. These have been supplied in response to an editorial request for such suggestions, made with a view to place the association on a high plane of usefulness, and to make it equal in all respects to other high-class engineering associations. The association was organized last summer, the project having been favorably regarded by leading houses in the heating trade. The contributions of practical suggestions under notice come from good sources, and show that the formation of such a society may conduce largely to the benefit of this branch of the engineering profession. The organization seems to be regarded as having started under favorable auspices, and has given already much encouragement to those who initiated the movement. One cannot read these suggestions without arriving at the conclusion that an organization of this kind is needed; and the hope that its future may be as brilliant as its advent has been timely and auspicious.

INDEX TO LEADING ARTICLES.

The journals quoted are indicated by initials, and their full titles are given in the opening pages of the Review. Other abbreviations are, Ill=Illustrated; W=Words.

Heating and Ventilation.

26421. The American Society of Heating and Ventilating Engineers. Suggestions for its Advancement (H & V-Oct.) 5000 w.

26789. Combination Heating. George Hoffman (N B-Nov. 10.) 1300 w.

26855. Ventilators (A An-Nov. 15.) 1200 w.

26861. Heating the Rosary Hill Convent. Ill. (Met W-Nov. 17.) 1200 w.

26904. Unusual Piping in a Hot-Water Heating Apparatus. Ill. (E R-Nov. 17.) 600 w.

26905. Modern Residence Heating Plant. Ill. (H & V-Nov. 15.) 3400 w.

26906. Warm Air Heating. Ill. (H & V-Nov. 15.) 2200 w.

*26916. Practical Suggestions Respecting the Ventilation of Buildings. John H. Kellogg (D E-Nov.) 5000 w.

27277. Defective Heating Boilers and Fittings (B J C-Dec. 1.) 900 w.

*27370. Domestic Boiler Explosions. Ill. J. Walker (I C B-Nov. 23.) 1500 w.

27419. Explosion of a Cast Iron Steam Heating Boiler. Uxbridge, Mass. (E N-Dec. 6.) 900 w.

Landscape Gardening.

26322. Transplanting Trees (G & F-Oct. 31.) 1200 w.

26779. The Pinetum at Wellesley. Ill. (G & F-Nov. 14.) 1300 w.

26780. Gardening at Newport (G & F-Nov. 14.) 1400 w.

27154. Accumulation without Disposition. M. C. R. (G & F-Nov. 28.) 1300 w.

Plumbing and Gas Fitting.

*26665. Plumbing Trade Schools and their Influence.—How they Promote Sanitary Science. E. N. G. Le Bois (E Mag-Jan.) 3000 w.

*26915. The Plumber's Relation to His Client and the Community in which He Lives. William P. Moffat (D E-Nov.) 1500 w.

Miscellany.

26909. Suggestions for the Advancement of the American Society of Heating and Ventilating Engineers (H & V-Nov. 15.) 2500 w.

Serials.

26907. Hot Water Heating and Fitting. J. L. Saunders (H & V-Began Nov. 15—1 part to date—15 cts).

26917. Combination Heating. By a Practical Furnace Man (D E-Began Nov.—1 part to date—30 cts).

26969. The Teaching of Plumbing Apprentices (I C B-Began Nov. 9—Ended Nov. 16—2 parts—30 cts. each).

27047. The New Rain Bath of the Utica State Hospital. Ill. William Paul Gerhard (E R-Began Nov. 24—Ended Dec. 1—2 parts—15 cts. each).

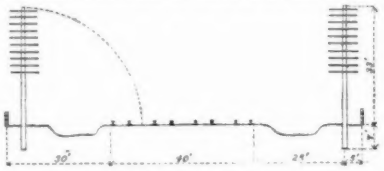
27214. Combination Heating. J. W. Hughes (Met. W-Began Dec. 1—1 part to date—15 cts).

We supply copies of these articles. See introductory

ELECTRICITY

Telegraphic Engineering and Construction.

ATTENTION was directed, in some remarks made in this department last month, to certain dangers due to the overloading of telegraph poles with wires—a practice which has become far too common on many of the principal routes of intercommunication in this country. Referring to this matter in its issue of November 10, the *Railroad Gazette* expresses the opinion that "the Western Union Telegraph company, like some railroads, has in many places devoted its energies to cheapening rates when it ought to have devoted them to improving the service." The *Gazette* further suggested that every railroad might at least have the poles set far enough from the track to avoid danger to trains in case a pole falls over. A correspondent, writing in the same journal of December 7, says: "I have long felt that the gigantic poles erected along the tracks of our trunk lines, and daily growing weaker, were a constant menace, to ignore which was to invite disaster. While it may not be practicable, at the present time, to force all poles back, as you suggest, we can and should insist upon rigid inspection, and the renewal of any pole showing signs of weakness." The same contributor—who is an executive officer of one of the principal New England railroads—states that but for the good judgment exercised by the men in charge of a fast freight on his road on the night of November 5, a disastrous wreck would have occurred from this cause. What this official says in reference to the dangers of the present situation is all true, but the evil is one which at best can only be partially guarded against by the most rigid inspection. A somewhat extended series of observations has led to the conclusion that it is impossible to construct a telegraph line according to present methods, carrying from 50 to 100 wires, in which the poles are not liable to give way, either by breaking off at the ground line or being pried bodily out of the earth, when the wires are heavily loaded with sleet or snow. A forcible example of this kind was noticed last winter, on the Lowell division of the Boston & Maine railroad at a point a few miles out of Boston, where a deep cut was literally filled for a quarter of a mile with the wreckage of an overthrown telephone line of very heavy and almost new poles carrying a large number of wires, but otherwise constructed in the best possible manner, causing a blockade of trains for a considerable time. Moreover it is seldom practicable to set the poles far enough away from the tracks to avoid the danger, as will clearly appear from the accompanying diagram drawn to scale, which illustrates a condition of affairs not at all uncommon in practice. The remedy, to be at all effectual, must be a radical one. The overhead lines along the railroad rights-of-way must be restricted to a safe number of wires, and when it becomes necessary to exceed this number, as in practice it often must, then resort must be had to underground construction. The alternative course, as we pointed out last month, is for the telegraph company to secure a right of way of its own between such cities as New York and Boston, or New York and Philadelphia. Three rods in width would be ample to provide space for all the lines likely to be needed for the next fifty years, and as the route could nearly all the way be carried through uncultivated land, the land damages would not be likely to exceed $30 per acre, or say $40,000 for the entire route between New York and Boston; by no means an onerous amount. In the immediate vicinity of large towns, undoubtedly some underground construction might



TELEGRAPH POLE SETTING.

be required, but the plan as a whole is entirely feasible, and ought to receive immediate consideration. There is no good reason why a telegraph line, any more than a railway, should be a mere tenant by sufferance, and dependent upon the good will of other corporations for its rights of way. Such a policy was very well so long as the number of wires required was not great enough to incommode or endanger the ordinary and legitimate uses of streets, highways and railways for purposes of trade and transportation, but in view of the unavoidable multiplication of wires at the present day, there would seem to be urgent need of some radical reforms in existing methods.

Electric Power on the Farm.

DURING the past three or four years there has been a considerable amount of talk, especially in the prospectuses of "fake" electric railroads and in the pages of popular magazines, of supplying electric power to farmers, especially those situated along the line of electric railways. It seems however, from an article in the *Street Railway Review* (November) that a promising beginning in this direction has already been actually made. The Crystal Hill farm and dairy, near Catasauqua, Pa., handles a large amount of corn-fodder and ensilage, and is provided with silos having an aggregate capacity of over 1000 tons. The expense of preparing the ensilage by horse-power was found to be very great and this led to the substitution of steam-power. An engineer had nevertheless to be employed, and all the coal used hauled a long distance by team, so that although steam proved to be cheaper than horse-power, the expense was still considerable. In the fall of 1892, an electrical contractor of Catasauqua induced the proprietors of the farm to try electricity. A 220 volt circuit 2½ miles in length was extended from the terminus of the lines of the local lighting plant, and a 5 horse-power direct-current motor was installed at the farm, which served to operate the churns, cream-separator, bottle-washer and ventilating fans during hot weather, while the same circuit furnished abundant electric light to all the farm buildings. This experiment proved so successful that the 25 horse-power steam-engine was soon afterwards replaced by a 10 horse-power motor of the same type as the first. The motor soon demonstrated its superiority over the steam-engine for the particular class of work it was called upon to do. Seventy head of milch-cows are fed on ensilage during the year, for which the adoption of the electric motor has reduced the cost of preparing the ensilage from $1.50 to 80 cents per ton. Threshing, wood-sawing, etc., are performed by the same power. In the same region, the Allentown stock farm of Hon. J. Roth has installed a 15 horse-power direct-current motor which takes current from the trolley line of the Allentown & Lehigh Valley Traction Company by a specially constructed single-wire line 3300 feet in length. The current is sold by meter at 8 cents per kilowatt hour. The motor is placed in a building back of the barn, and belted to a main shaft supplied with pulleys for operating various kinds of farm-machinery. Threshing, cutting feed, grinding grain, shelling corn, pumping water, sawing wood, etc., are done in this way. A barn 50 by 208 feet is also supplied with electric lights. Mr. Roth says that he finds that electricity is not only much cheaper than steam or horse-power, but that it is far more convenient and more safe. He is strongly recommending other large farmers in his vicinity to adopt it.

The Architect and the Electrical Engineer.

THE Interdependence of the Architect and the Electrical Engineer is the topic of a thoughtful article by Professor F. A. P. Perrine, in *Electrical Engineering* (November). The author thinks that the reluctance of architects to undertake the study of the details of electric lighting systems has been largely responsible for the slow progress of electricity in the household. He points out that the problem of lighting any one of the larger class of office buildings now existing in half a dozen of our chief cities, is not inferior in importance or difficulty to the problem of furnishing light for a town of six or eight

thousand inhabitants. An architect who undertakes to make plans for such a building ought to make himself familiar with the design, construction and maintenance of a very considerable central station for supplying it with light. Then there are the questions of telephone and signal service, of electric elevators, and so on. "Shall we say then"—says Professor Perrine—"that either our architects must become one of the electrical profession, or that it will be necessary for the electricians to study architecture? Both these propositions seem to ask for more ability and diversity of training than should be expected of one man in either profession." The best solution of the problem, the author thinks, is to be looked for in the direction of a better mutual understanding between the architect and the electrical engineer when working together upon the same design. "It should not be necessary for the electrician to search in vain on the plan for space in which to run his wires. The architect should understand the reasonableness of fuse-wires and junction-boxes, and he should be capable of understanding that there is a limit to the inaccessibility of the location in which a dynamo can be erected and properly cared for. . . . . , with the advent of the trained electrical engineer the members of the profession have reached the dignity where they may reasonably expect to be called into consultation with members of other professions on an equality, and where the interdependence does not mean amalgamation, but intelligent joint authorship." That is to say, the collaboration for which Professor Perrine makes his plea should be similar in its character to that which exists, for example, between the designers of the hull of a steamship and the designers of her engines and machinery. It is apparent that only in some such way can a thoroughly satisfactory result be reached, especially in the case of a large building or group of buildings. A competent architect, in the present state of knowledge, ought at least to be able to present a design in which the demands made upon the electrical engineer do not involve either impossibilities or unnecessary inconveniences.

Continuous vs. Alternating Arc Lights.

"A DIFFERENCE of opinion seems still to exist"—says Professor J. A. Fleming, in *Lightning*, the paper being reprinted in the *Electrical Review* (November 14)—"as to the relative advantages of the continuous and the alternating current arc as regards efficiency of illumination." As a contribution to the scanty stock of accurate knowledge now accessible on the subject, Professor Fleming gives a résumé of certain experiments made by him in order to ascertain the relative efficiency, measured in candle-power, of one and the same form of arc-lamp, when supplied successively with continuous and alternating currents. A special photometer was prepared for the purpose of measuring the intensity of the light at any degree of inclination to the horizon. In all the experiments, carbons of 13 millimeters were employed, and a wattmeter was connected directly to the carbons, so as to measure the energy actually expended in the arc itself. From the results of several hundred observations, a series of curves was constructed, showing, first, the relative distribution of light corresponding to a given "wattage" at different inclinations to the horizon, and second, the variations in mean spherical candle-power corresponding to the different watt-values of energy expended in the arc. The former showed, as might perhaps have been foreseen, that the greatest intensity of light is projected at an angle of about 48° from the ground line, while the second set of observations demonstrated that for a given expenditure of power in the arc, the mean spherical candle-power for the alternating current is less than that for the continuous in the ratio of about two to three. Apart from scientific measurements, it is the general experience of people, where alternating arcs are used, that although the lamps look bright enough to the eye, the illumination at the ground level is disappointing. The diagrams accompanying the paper show that with the alternating arc, the total illumination is divided equally about at the horizontal

plane, half of it being projected upward at nearly the same angle, viz.: 48°. Hence if the quantity of light directly available for lighting a floor-space be considered, the comparative efficiencies of the continuous and alternating arcs are in the ratio of 6 to 2. The difference in practice need not be so great as this, because the light thrown upward may easily be reflected downward by means of a suitable reflector placed above the lamp, although it is obvious that if even the whole of this light could be usefully employed, the original ratio cannot be increased. Furthermore, Professor Fleming ascertained from experiment, that while a certain continuous arc required 8.25 amperes and 45 volts to give a particular candle-power, the alternating arc absorbed 15 amperes and 37 volts in producing an equal illumination, the apparent watts being in the ratio of 372 to 555. Against these various disadvantages, says Professor Fleming, may be set off the great convenience of having only one set of circuits. This has led to the employment in some instances of alternate currents for direct-current lighting by means of rectifiers, the irregularities of which have been found to assist the operation of the feeding-gear of the lamp.

Electricity on Shipboard.

IN the *Electrical-Engineer* (November 21) Lieut. S. Dana Greene's paper read before the Society of Naval Architects and Marine Engineers on the present position and future development of electrical appliances on shipboard, is given in abstract. The electrical plant has come to be considered one of the vital necessities of the modern war-ship, and is therefore always located in a special compartment by itself, as nearly in the central portion of the ship as possible, and below the protective deck. Vertical engines are to be preferred, and the dynamos should always be direct-coupled. Compound-wound slow-speed multipolar types of dynamos are best for marine purposes, and the full load efficiency of each unit should not be less than 80 per cent.; in the best types in modern service it often runs as high as 83 to 85 per cent. The wiring of the vessel is the most difficult and expensive, as well as the most important part of the installation. The practice, formerly in favor in Europe, of utilizing the hull of the vessel as the return conductor has never been admitted in this country; its sole advantage consists in its cheapness, while on the other hand it has a number of serious faults. The lights should be grouped on a number of separate circuits which are united at the switchboard, those ordinarily used at the same time being arranged on the same circuit. Water-tight moldings and fittings are employed in all exposed places. The best rubber-covered wire is used, to which a good heavy coating of braiding is found to give all the mechanical protection necessary. The loss of potential in the wiring should never be permitted to exceed 5 per cent., and can usually be limited to 3 per cent. without excessive cost. The e. m. f. of all U. S. naval plants is 80 volts; a standard which has been adopted in order to permit the use of search-lights and incandescent lamps on the same dynamos, without interposing too much dead resistance in the search-light circuit. This reason does not apply to merchant vessels, in which the voltage may with advantage be made from 100 to 120. The most important future developments in marine applications are probably to be looked for in connection with the electric motor. The motor is well adapted to operate ammunition hoists, as well as the turrets of battle-ships and the heavy guns in the turrets. Ventilators, portable drills and pumps, deck hoists, and even steering-gear may be advantageously operated by electric motors. One most important suggestion of the author is that all the water-tight doors in a vessel might easily be opened and closed from a single point and with great celerity. If the ill-fated *Victoria* had been thus equipped, her compartments might all have been closed before the collision took place, and the ship saved. Among the most useful of recent electrical applications are electric search-lights and range-finders. The latter instrument will indicate quickly and with reasonable accuracy, the distance of any object at sea within the range of vision; often

a matter of the greatest importance. It is likely to play an important part in future naval engagements, and may in some instances be the controlling factor in the determination of the result of the contest. Other minor applications of electricity pointed out or suggested by Lieut. Greene, constitute no inconsiderable part of the equipment of these modern fighting machines.

Conduit Electric Railways.

AT a recent meeting of the New York Electrical Society, Mr. Joseph Sachs read an exhaustive paper on the subject of electric railway conduit systems, which may be found in *Electricity*. The paper was fully illustrated, and describes in a clear and accurate manner the many principal plans which have thus far been proposed, and intelligently outlines the prospects for the future. Fortunately, the paper elicited a full and animated discussion, which was participated in by some of the leading authorities in the country. The general consensus of opinion among those best qualified to judge, appears to have been that there is no serious obstacle other than cost in the way of constructing a conduit system that will work. It must be admitted that the constructional difficulties are far greater than in the overhead system, but all these may be overcome if enough money is expended in the solution of the problem. This is particularly the case in respect to the electrical problems, but as Mr. Sachs points out, if the conduit be made large enough, and the voltage be reduced to a sufficiently low point—which involves of course, a material increase in the cost of copper for conductors—these difficulties are minimized, and may undoubtedly be overcome. There is scarcely a practicing electrical engineer in the country who, if asked whether it were possible to construct an operative electric railway upon the conduit plan, would not answer unhesitatingly, "Yes." Why then has not this method become more popular? Simply because it is in competition with a better method. There is but one single feature of the conduit that recommends it above the overhead trolley, and that is one that appeals to the esthetic side of our natures alone. In all other particulars the overhead system stands *facile princeps*. It cheaper to construct; it is simpler, both mechanically and electrically; it gives better service, and what is more important for its survival, it is a better dividend payer. What incentive, therefore is there to capital, to an investment of half-a-dozen or more times the money for something which even in its ideal perfection can only hope to equal that which we have already? Obviously, little or none.

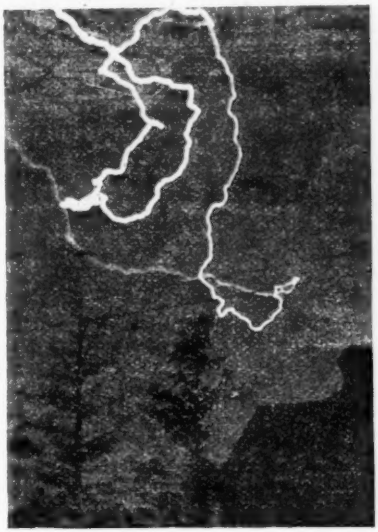
Electric Power Transmission in California.

THE *Practical Engineeer* (November 2) contains a detailed account of an electric transmission plant at Bodie, Cal., by Mr. T. H. Leggett, which does not appear to have been published in the electrical journals of this country. The single-phase synchronous system is used, the distance being 12½ miles. The available head of water is 350 feet, which drives four 21-inch Pelton wheels rated at 60 horse-power each. These are on a common axis and are coupled direct to the armature shaft, the rate of revolution being from 860 to 870 per minute. A Doolittle differential governor is employed, and is found to do its work in the most satisfactory manner. The generator is a 12-pole 120 k. w. machine, and is insulated from the water-wheels by a hard-rubber disk enclosed in a rigid coupling. Its potential under full load is 3530 volts. The line is of No. 1 soft copper, supported on heavy poles placed 100 feet apart, and crosses a number of very steep ridges, one of which is the summit of the Sierra Nevada range. Deep-groove glass insulators on iron pins are used. A motor of 120 horse-power drives the 20-stamp mill of the Standard Consolidated Mining Company at Bodie. The mill and offices are lighted by 100-volt incandescent lamps, taking current from a 100-light converter at a reduction of 30.1, which is connected to the main line before reaching the motor-switchboard. The results of numerous tests are given, showing that about 70 per cent. of the water-power is obtained at the motor pul-

ley. The entire cost of the plant is stated to have been less than $45,000, while its operation, during a single month, effected a saving of about $2200. The daily saving over the use of steam is from $35 to $40, on a twelve-hour run.

How Lightning Strikes an Electric Line.

ONE of the most curious and remarkable photographs of a flash of lightning which has ever come under our notice was recently secured by Mr. Richard Rea of Menominee, Mich., and forwarded to the *Electrical Review*. By courtesy of the *Review* we are enabled to reproduce the illustration, which appeared in its issue of



November 14. A careful examination of the photograph will show that the character of the flash was spiral, and that its direction was away from the camera, the large irregular loop in the upper part of the picture being quite near the spectator. From this loop the discharge passed downward and in front of the three electric wires, being deflected slightly from its course by the repulsive effect of the current flowing into the upper wire, and again deflected, still more sharply, by the attractive effect of the current in the lower wire, of opposite polarity (the wires are stated to be those of a three-wire low-tension system). It then passed up in front of and over the neutral wire, taking a turn completely round it, and then going behind the two upper wires away into the distance, with greatly diminished brilliancy and intensity, showing that it had parted with a considerable volume of its original energy, which was carried away by the neutral wire. This photograph is a most valuable contribution to the mass of facts respecting the action of lightning which has been in course of accumulation within the past few years. It will be interesting to hear what the experts in this line are able to learn from it.

Determining the Efficiency of Electric Motors.

ONE of the most intelligently and clearly written explanations of the how, why and wherefore of testing an electric motor for determining its efficiency which we have ever met with, is given by James F. Hobart in the *Safety Valve* (November). Mr. Hobart's article presupposes a knowledge of elementary mathematics, but to one who has mastered these, the instructions and explanations will be found quite sufficient for a complete understanding of the subject, although the meaning of the author is unfortunately obscured by the repeated occurrence of the word "tongue," which the intelligent compositor has thought fit to substitute for "torque." Nor would it have done any harm if the author had given, in a foot-note or otherwise, some explanation of the meaning of this expression which, although well enough known in former days to theoretical machinists, did not make its appearance in the work-shop until the advent of the electric motor. With reference to the use of technical terms it may be appropriately added that new ones are constantly appearing, and new uses are found for those already in use; and it renders any exposition more acceptable if the significations of such terms as have not yet found their way into dictionaries are briefly and clearly defined in the significations employed. Even if some terms are unnecessarily defined no harm would result.

INDEX TO LEADING ARTICLES.

The journals quoted are indicated by initials, and their full titles are given in the opening pages of the Review. Other abbreviations are, Ill=Illustrated; W=Words.

Lighting.

*26762. The Electricity Works at Bolton. Ill. (E E L-Nov. 2.) 6000 w.

26851. The Perrine Scale for Wiring Calculations. Ill. (E E N Y-Nov. 14.) 300 w.

26889. Profit in Small Lighting Plants. J. C. Pratt (S M-Nov. 15.) 900 w.

*26939. The Electricity Works at Southport. Ill. (E E L-Nov. 9.) 3000 w.

27006. The Windmill Electric Lighting Plant at Marblehead Neck, Mass. Ill. (E E N Y-Nov. 21.) 1000 w.

*27096. Hampstead Central Station. Ill. (E E L-Nov. 16.) 1400 w.

*27126. Distribution of Light from Arc Lamps. Ill. Rankin Kennedy (E R L-Nov. 16.) 500 w.

*27132. An Outstanding Problem. Editorial. (El-Nov. 16) 1800 w.

27163. Electric Lighting by Windmill Power. Bell Crank (A M-Nov. 29.) 1400 w.

27209. High Candle Power Gas Rivalry. H. W. Frund (E W-Dec. 1.) 1000 w.

*27293. Lighting Installations. H. A. Henderson, with Discussion (El-Nov. 23.) 2600 w.

27429. Distribution of Light, Heat and Power at the Kalamazoo Insane Asylum. Ill. (W E-Dec. 8.) 3500 w.

27436. Suggestions for Buffalo's Electrical Carnival. Ill. Frank C. Perkins (E W-Dec. 8.) 900 w.

Power.

*26662. Operating Machine Tools by Electricity. Ill. George Richmond. (E Mag-Jan.) 3000 w.

*26736. An Electric Power Transmission Installation.—In the Mining District of Bodie, in California (P Eng-Nov. 2.) 1500 w.

*26756. Progress of the Electric Locomotive (Inv-Nov. 3.) 1900 w.

*26882. Selling Power for Outdoor and Farming Purposes. Ill. (S R R-Nov.) 800 w.

†26922. Some Facts About Polyphase Motors. Louis Bell. (T A I E E-Nov.) 4000 w.

†26924. Experiments on Two Phase Motors. Ill. Dr. Louis Duncan, S. H. Brown, W. P. Anderson and S. Q. Hayes, with Discussion (T A I E E-Nov.) 4800 w.

26935. Motors: Their Efficiency and How Determined. James F. Hobart (S V-Nov. 15) 2700 w.

*26978. A Few Remarks About Accumulators (E R L-Nov. 9.) 1100 w.

*27122. Progress in Electrical Transmission. The Latest Improved Plant, West Pullman, Ill. Ill. (M-Nov. 15.) 2000 w.

27192. The Kearney, Neb., Water Power. Ill. (E E N Y-Nov. 28.) 800 w.

27193. Woonsocket Electric Company's New Water Power Plant. Ill. (S E-Nov.) 700 w.

27196. Electric Elevator Performance (S E-Nov.) 1000 w.

27201. Accidents in Large Power Plants. Ill. (W E-Dec. 1.) 800 w.

*27291. Notes on Rotary Field Motors. Silvanus P. Thompson (El-Nov. 23) 2500 w.

*27335. Non-Synchronous Alternating-Current Motor for High Pressure. Ill. (E E L-Nov. 23.) 500 w.

27437. Wire Losses, Over Compounding of Dynamos, and Regulation of P. D. in Multiple Arc Circuits. E. P. Roberts (E W-Dec. 8.) 1600 w.

Telephony and Telegraphy.

26727. The Minimum Current Audible in a Telephone. Arthur Vaughn Abbott (E E-Nov.) 700 w.

26791. The Telephone in War (E R N Y-Nov. 14.) 500 w.

26956. A Resurrected Chapter in the History of the Invention of the Telegraph. G. Wilfred Pearce (E N Y-Nov. 21.) 700 w.

26962. Telephoning Election Returns (E R N Y-Nov. 21.) 1500 w.

27191. The Early Morning Test in Telephone Offices. Ill. J. W. Manson (E E N Y-Nov. 28.) 700 w.

27246. The Telephone Door. Angus S. Hibbard (E E-Dec.) 2200 w.

27278. A Novel Use for Telephones.—To Bring Warning of Coming Earthquakes (B J C-Dec. 1.) 500 w.

*27348. The National Telephone Company's New Exchange. Ill. (E R L-Nov. 23.) 1800 w.

27382. Telegraphing Without Wires. Ill. Erich Rathenau (E R N Y-Dec 5.) 1200 w.

†27407. Proposals for the Canadian Pacific Cable (I R W-Dec. 10.) 1000 w.

Miscellany.

26726. The Interdependence of the Architect and the Electrical Engineer. Frederic A. C. Perrine (E E-Nov.) 800 w.

26728. Electricity: Its Social and Political Influence. George Iles (E E-Nov.) 800 w.

*26749. Note on the Measurement of Insulation and Other Resistances. Ill. Albert Campbell (El-Nov. 2.) 500 w.

*26778. Electrical (So-Called) Body Appliances. H. Newman Lawrence (E R L-Nov. 2.) 2700 w.

26792. Continuous and Alternate Current Arcs. Ill. J. A. Fleming (E R N Y-Nov. 14.) 2600 w.

26797. Speaking Along a Ray of Light. Ill. Nelson W. Perry (E N Y-Nov. 14.) 2300 w.

*26814. Alternators for Central Stations (E P-Nov.) 1500 w.

We supply copies of these articles. See introductory.

26863. Electrical Fires. Ill. (W E-Nov. 17.) 2800 w.

*26880. Absurdity of the Recent Rules Adopted by the Underwriters International Electric Association, Covering the Use of 500-Volt Fuses. W. E. Harrington (S R R-Nov.) 2000.

26888. Dynamo Currents for Fire Alarm System. B. S. Flander (F W-Nov. 17.) 1000 w.

†26923. On the Law of Hysteresis, and the Theory of Ferric Inductances. Charles Proteus Steinmetz, with Discussion (T A I E E-Nov.) 4800 w.

*26942. The Electric Conductivity of Pure Water. J. W. Rodger (N-Nov. 8.) 1400 w.

26961. The Treatment of Sufferers by Accidental Electric Shock (E R N Y-Nov 21.) 1800 w.

*26988. On the Refraction and Dispersion of Rays of Electric Force. A. Garbasso and E. Aschkinass (El-Nov. 9.) 1600 w.

27008. Electricity on Shipboard. S. Dana Greene (E E N Y-Nov. 21.) 1800 w.

27017. Fusion and Volatilization Produced by Means of the Heat of the Electric Arc. Henri Moissan (Sc A S-Nov. 24.) 2000 w.

27136. Killing by Electricity (E R N Y-Nov. 28.) 1300 w.

27181. Some of the Less Understood Electrical Phenomena—The Alternating Current and Its Manifestations—Electro-Magnetic Induction. Nelson W. Perry (E N Y-Nov. 28.) 2200 w.

27200. Electrical Production of Ozone for the Treatment of Disease. Ill. (W E-Dec. 1.) 1000 w.

27206. The Definition of Reactance. C. P. Steinmetz and Frederick Bedell (E W-Dec. 1.) 1400 w.

27247. Concerning Electrical Fads. Louis Bell (E E-Dec.) 1000 w.

27256. "What Is Electricity?" What Electricity Is. John M. Bachelor (E A-Dec. 1.) 350 w.

*27271. The Electrical Accident in Cannon Street (Eng L-Nov. 23.) 2400 w.

*27292. Researches on the Occlusion of Electrolytic Gases by Porous Bodies, Especially by Metals of the Platinum Family: Its Application to Gas Batteries and Pressure Electric Accumulators. L. Cailletet and E. Collardeau (El-Nov. 23.) 1500 w.

*27334. On the Effect of Magnetization upon the Dimensions of Wires and Rings of Annealed Iron. Shelford Bidwell (E E L-Nov. 23.) 1700 w.

*27346. Theory and Practice in Electrical Engineering. Rankin Kennedy (E R L-Nov. 23.) 1600 w.

*27347. Experiments in the Utilization of Chemical Energy for the Production of Electricity. Ill. (E R L-Nov. 23.) 1000 w.

†27377. An Improved Form of Interrupter for Large Induction Coils. Ill. F. L. O. Wadsworth (A J S-Dec) 1600 w.

27396. Light Without Heat. Nelson W. Perry (E N Y-Dec. 5.) 1800 w.

27410. Armature-Disc Cutting. Oberlin Smith (E E N Y-Dec. 5.) 2200 w.

27411. Some Aspects of Electrical Education. W. M. Stine (E E N Y-Dec. 5.) 3300 w.

27435. Electrical Differences of Potential—An Analogy. John Waddell (E W-Dec. 8.) 1350 w.

27438. Transformer Testing. Eustace Oxley (E W-Dec. 8.) 1000 w.

Serials.

22059. Practical Notes on Dynamo Calculations. Ill. Alfred E. Wiener (E W-Began May 19—20 parts to date—15 cts. each).

22131. The Incandescence Lamp. Ill. A. Bainville (E R L-Began May 11—7 parts to date—30 cts. each).

23866. Electrodynamic Machinery. Ill. E. J. Houston and A. E. Kennelly (E W-Began July 21—18 parts to date—15 cts. each).

24536. Principles of Dynamo Design. Newton Harrison (E A-Began Aug. 25—14 parts to date—15 cts. each).

25095. Postal Telegraphs. Ill. James Bell (E L-Began Sept. 7—12 parts to date—30 cts. each).

25105. Standard Units for Electrical Measurement. Ill. (E R L-Began Sept. 7—5 parts to date—30 cts. each).

25193. Electrical Machinist Practice. Ill. James F. Hobart (E E N Y-Began Sept. 19—12 parts to date—15 cts. each).

25482. The Chemical Theory of Accumulators. E. J. Wade (El-Began Sept. 21—6 parts to date—30 cts. each).

25895. The Design and Specification of Electric Lighting Works for Architects and Civil Engineers. Ill. Howard Pentland and Alfred H. Gibbings (E L-Began Oct. 5—8 parts to date—30 cts. each).

26235. The Diseases of Dynamos (E R L-Began Oct. 19—Ended Nov. 2—3 parts—30 cts. each).

26377. Resonance Analysis of Alternate Currents. M. I. Pupin (A J S-Began Nov.—2 part to date—45 cts. each).

26518. The Surplus and Deficit Theory of Electricity. W. Perren Maycock (E E L-Began Oct. 26—Ended Nov. 23—4 parts—30 cts. each).

26592. Electrical Power Transmission. Ill. Louis Bell (E W-Began Nov. 10—3 parts to date—15 cts. each).

26945. Electricity on Board Ship and Its Application as Motive Power for Auxiliary Machinery. Alfred H. Gibbings (E L-Began Nov. 9—3 parts to date—30 cts. each).

26986. Principles of Transformer Design. Ill. Alfred Still (El—Began Nov. 9—Ended Nov. 23—3 parts—30 cts. each.)

27371. The Electric Light. Henry Stooke (I C B-Began Nov. 23—1 part to date—30 cts).

INDUSTRIAL SOCIOLOGY

May a Man Conduct his Business as He Please?

WHAT may a man do with his own? It is a popular idea, and a popular expression also, that "a man may do what he pleases with his own"; yet there are certain legal limitations which a man attempting to apply such a rule in conduct will soon be made to realize, and certain moral obligations to society and to humanity in its broadest sense,—obligations which cannot practically be made the subject of legal enactment,—yet whose violation will entail the loss of social respect and the disapproval of just and humane men the world over.

A man's fist is his own, yet he may not from anger or malice use it to smite a fellow citizen, without exposing himself to a penalty for the act. Except in self-defense he may not assault his neighbor with violence. His house is his own, yet he may not at will use it for a brothel or a gambling house. No matter how sound may be the title to his property, if certain maladies appear in his dwelling both he and his family may be shut up in his own house and kept there secluded from personal communication with neighbors until the house has been purged of contagion; or they may be removed to a pest house when it is necessary to prevent the spread of a dangerous disease. These are familiar examples of limitations which may restrain men from doing absolutely what they will with their own. Many other limitations to rights of personal ownership exist in the statutes of all civilized countries. The right of absolute control under all circumstances does not legally exist anywhere except among savages; and even with savages some rudimentary limitations to rights of ownership may be found.

This line of argument has been followed out with severe logic by Hon. Carroll D. Wright in *The Forum* for December, and the argument points directly toward modern business methods. He evidently thinks the recognition of ethical principles on the part of employers of labor will ultimately be forced by public opinion, though confessing, that, from an economic point of view, there is no visible way to bring about such recognition. At the same time if ethical principles are to exert an influence on employers they must simultaneously react upon the employed. The subject is so thoroughly elaborated that it is not easy, in a review, to present a fair view of it, but it will be possible to reflect the more important points of the argument.

"Shall a man conduct his own business in his own way? Shall the savings of labor be considered a reserve, from which labor must draw, in order to enable it to subsist during periods of depression or of adversity, while the reserve of capital is kept practically intact under like circumstances, or, if drawn upon at all, in less measure than labor draws upon its savings?"

"The great employer of to day, when asked to make some concessions to labor or to arbitrate differences which have arisen between him and his employés declares that in order to win success he must have complete control of his own affairs; and he asks, 'Shall I not conduct my own business in my own way?' Under some circumstances the employé asks, 'Have you the right to conduct your business in your own way?' Society has long since answered these questions in some important particulars. It says to the property owner, the manufacturer: 'You must not so conduct your business as to injure the property of your neighbor, nor must you conduct your business in such a way as to injure the health of your neighbor. No property owner can do anything that will interfere with the rights and privileges of his neighbor, whether these rights and privileges come under the head of right to freedom from injury to property, or the privilege of living without damage to health.' These principles are so old, and so well defined by precedent and by stat-

ute, that the answer is complete and emphatic in so far as the two features named; and no question is made as to the soundness, either in ethics or economics, of the position which society has taken in the premises. . . . But the question which is far more reaching, and which will inevitably be answered by society, relates to conditions of men rather than to their material surroundings; and this question: 'Shall a man or a corporation who does not, or is not able to, conduct his or its affairs so as to avoid public disturbance, obstruction of trade, loss of wages, or the lowering of the standard of living, be free from the interference of society?' Will not communities say to the employer: 'If you cannot so conduct your business, or manufacture, or railroad that public business be not disturbed or the standard of life interfered with, we shall take some part in the management, or insist upon some adjustment by which society shall be free from disturbance?' The broad answer will come in due time,—in fact, it has come,—not by revolutionary methods, but by the processes of reason, the application of justice, and the rule of right."

It is argued that consent to arbitration of differences between labor and capital is a tacit reply in the affirmative to the questions propounded, as is also the existence of State Boards of Arbitration, under legislative enactment the constitutionality of which cannot be denied. The Interstate Commerce Law is a "clearly defined instance of the necessity of government interference to prevent disturbance of trade. If it can interfere to prevent the disturbance of trade, can it not interfere to prevent the disturbance of society? Cannot the State say to both labor and capital, 'You must so conduct your affairs as to leave people at peace'? It must be admitted at once that, in so far as the individual is concerned, the extension of this answer to the scope which it will take in the future is uneconomic. It is not good political economy, perhaps, but is it not good ethics?"

The position is taken and ably maintained that the savings of labor is one of the "reserves as essential to the integrity of the business of a community as the reserves of capital," or "the undivided profits of business held by capital for legitimate purposes. "The trouble comes when, through depression, through competition, or other circumstances, wages are reduced; and, in so much as they are reduced, the possibility of keeping labor's reserve intact is lessened. If the necessity extend or continue, the possibility of keeping the reserve intact is not only lessened, but completely destroyed; and, in order to keep in condition to earn even enough wages to come up to the life-line, the reserves are drawn upon and in many cases entirely exhausted, in order that the processes of production may go on. Capital, in the meantime draws upon its reserves to sustain its productive processes, while it may and often does reduce the usual dividends; and sometimes its dividends may be wiped out completely, just as the surplus earnings of labor may be wiped out completely. But recently we have seen that labor has not only been obliged, under the depressed condition of business, to accept most serious reductions in wages, but to draw heavily upon its reserve; while capital not only preserved its reserve intact, but did not suffer materially in its dividends, although it did meet current losses in its production."

Is this state of things fair to labor? If not, can legislation change the condition, or must the change come through the powerful influence of public opinion? A man may do anything with his property that statute law, as administered in law courts, permits, yet if he does not set some other than legal bounds upon conduct, he will incur social penalties that to many men are as hard, perhaps harder to bear than those imposed for legal offenses. To lose self-respect, the respect of neighbors, to feel that one's name is spoken only with contempt, to become ostracized from the esteem of honest, honorable men, to realize that one has by his selfish disregard of public opinion alienated himself from the esteem of worthy people, to be shunned by those whose society is desirable, to be black-balled in clubs, and cut in public places; these are penalties of an un-

written code whose restraining power upon conduct is, except upon the lower types of moral development, more potent than that of statute law. The force of this unwritten law is felt everywhere above the stratum of crime in society, and it is an axiom that "there is honor even among thieves."

It is wholly impracticable to regulate by statute all the actions of men. It is desirable that people should treat each other with politeness, yet it would be foolish to attempt to make people polite by legislative enactment. Statute law imposes penalties for lying, only in two cases, lying under oath upon matters material to a legal issue, and lying about any of the things specified in statutes relating to slander or libel. In all other matters a man may lie without incurring a legal penalty; yet over the wilful, habitual liar hangs the penalty of the contempt which all honorable men accord to habitual liars. This fact, that there are and must always be two kinds of law by which men are controlled in their dealings with each other, statute law and moral law, which latter should be identical with the law of honor, seems to have been lost sight of by some writers in dealing with the sociological questions now uppermost in public interest.

The cry is for more legislation, more statute law, and for the most part the proposed legislation is of a nature which the history of mankind has over and again demonstrated to be impracticable. As a matter of fact there now exist statutes intended to control certain matters that would be much better governed by the law of public opinion in the absence of statutory provisions regarding them. Good government suffers more through excessive legislation than for any lack of legislation.

The law of human kindness, too much forgotten in the pull and push of modern trade, is the only law that can regulate the intercourse between employers and employed. This, though not expressly stated in Mr. Wakeman's paper, printed in this Magazine for October, is implied in all he says with reference to the treatment which employers are morally bound to accord to workmen in shops and factories. Judge Trumbull recognizes this when in his speech delivered recently before an audience of populists in Chicago he says:

"I would call upon the millionaires for heaven's sake to pause in their greed for more millions, and unite in the passage of laws which, by securing equal opportunities to all, shall contribute to the happiness of all."

But even were it possible to pass laws that would equalize opportunity, no legislation can equalize the ability of men to acquire, and supreme selfishness combined with business foresight would still lead in the race for wealth. If supreme selfishness, by an improved standard of morality and honor, could be made as disreputable as cheating and lying now are, there would be fewer millionaires.

Mr. Ashley, in his paper reviewed in November, evidently sees the need for improvement in business morality, when he speaks of fairness as an element of success in his scheme of profit sharing. Nothing could be truer; but, if fairness in dealing were a ruling motive on both sides at the present time, all difficulties between employers and the employed could be easily and amicably settled. Fairness in dealing implies a plane of morality on which supreme selfishness cannot stand. If all employers could attain to this plane of morality, each would be solicitous that employés should get their full and just share of the products of their labor. If all employés stood on this plane, every man of them would constantly study how to render the full equivalent of service for wages received. As it is now, the majority of both employers and employed in dealing with each other are governed by supreme selfishness, each seeking to give as little as possible for what he gets regardless of the golden rule. On this higher plane, a combination of men after having amassed many millions of dollars through the assistance of employés, would not cut wages to the starvation point, when the maintenance of wages through a streak of hard times seemed likely to take away an inconsiderable fraction of those millions and distribute it among those who in prosperous times had helped to create them.

Until both employers and wage earners

have been elevated to this higher plane of morality, all laws intended to promote a more uniform distribution of wealth will fail. The principles of equity must become a general rule of action, else all laws of this kind will be evaded, and if this rule prevailed there would be no need of the laws. There are laws against usury; yet, when any man wishes to pay more than the legal rate for the use of money, he can always find a lender who will advance the money wanted, on sufficient collateral security, and do it in a way that the law cannot reach. Our usury laws are good examples of the impracticability of all laws whose effective execution is not backed by a positive and general current of public opinion.

The Chicago Strike.

WHEN some future historian shall write a history of the world, recording the events of the last decade of the nineteenth century, he will find in the annals of the year 1894 abundant material for a most interesting chapter. The great commercial depression, the war between Japan and China, and its results, the onward march of scientific discovery, the great engineering works in progress, the futile struggle for efficient tariff reform in the congress of the United States, the unrest of the masses, culminating in the great strike at Chicago, are events numerous and important enough to inspire a masterpiece of historical description.

In writing about the strike our supposed historian will find no better material than the official report of the United States Strike Commission appointed by the President, July 26, 1894. This commission, consisting of Carroll D. Wright, U. S. commissioner of labor, John D. Kernan of New York, and Nicholas E. Worthington of Illinois, have submitted a report to the President which fills a pamphlet of 52 pages. *The Boston Journal of Commerce* (Nov. 17) contains a comprehensive abstract of the document.

In a session of thirteen days, 107 witnesses were examined. A copy of the testimony thus obtained was transmitted with the report, and it substantiates all the statements made in the report as submitted. Briefly then, the history of the strike will be based on the following facts.

The employés of the Pullman car company very generally joined the American railway union in March and April, 1894, and the nineteen local unions thus formed declared a strike at Pullman, hoping thereby to force the Pullman car company to accede to certain demands made by the workmen, the chief of which was an increase of wages, that on account of the effects of commercial depression upon the business of the company had been severely cut.

The General Manager's Association is a voluntary unincorporated association founded in 1886, having as members the twenty-four railroads centering in Chicago, together operating 40,933 miles of road, having a total capitalization of $2,108,552,617, and giving employment to 221,097 men. The object of the organization is, ostensibly, "the consideration of problems of management arising from the operation of railroads terminating or centering at Chicago." Upon this organization the significant comment is made that "there are no limitations as to consideration of problems or of funds (raised by assessment divided equally among the members) except the will of the managers and the resources of the railroad corporations."

The Pullman Car Company was organized in 1867, with a capital of $1,000,000. Its present paid up capital is $36,000,000. The profits of the business have permitted the payment of 2 per cent. quarterly dividends and the accumulation of a surplus of $25,000,000, undivided profits. For the year ending July 1, 1894, the dividends considerably exceeded one half the wages paid for that fiscal year. The business of the company is as follows:

"(1) The operation of its cars upon about 126,000 miles of railroad, being about three-fourths of the railway mileage of the country, under contracts similar to that in evidence. (2) The manufacture and repair of such cars. (3) The manufacture of cars of all kinds for the general market. (4) The care and management, as owner and landlord of the town of Pullman."

Not to go into the details of the history of the erection of the town of Pullman by the Pullman Car Company, some of its peculiar features may be noted. It is a town where no workman employed by the company can acquire ownership of real estate. The rentals collected from workmen are about 25 per cent. higher than for the same grade of dwellings in Chicago. All library privileges, etc., if used, are paid for by the user. If workmen are injured in the service of the company they must be attended by a surgeon provided by the company, whose duty is, also, "to secure from the injured party a written statement as to the causes of injury, and it is his custom to urge the acceptance of any offered settlement." This system is characterized as "admirably conceived from a business standpoint to secure speedy settlement of claims for damages upon terms offered by the company, and to protect it from litigation and its results." In short, it appears from the report, that the scheme of the city of Pullman, was only intended to subserve the interests of the Pullman car company, and to aid in the control of the skilled labor that could be attracted to the town.

The American Railway Union is an association of about 150,000 railroad employés, organized June 20, 1893, including railway employés born of white parents. One of its avowed purposes was to prepare railway employés to meet with united resistance any unjust restriction or regulation which the organization of general managers might impose; and although the American Federation of Labor, with a membership of 500,000, at one time seemed willing to support the strike, the main contest was between the General Managers' Association and the American railway Union. The strike utterly failed to accomplish its purpose. The condition of the striking employés of the Pullman Car Company was rendered worse by it, while the commerce of the country was seriously deranged. The cost of the strike affected by it is summarized as follows: Hire of United States deputy marshals, and other incidental expenses at least $685,308. Loss of wages by workmen at Pullman, at least $350,000. Loss of earnings by railway employés, $1,389,143. Many of the latter are still adrift and losing wages. Other widely distributed losses cannot be more than guessed at. There were shot and fatally wounded, 12; number arrested by the police, 575; number arrested and indicted under United States statutes, 71; number arrested but not indicted, 119.

"These great losses and many crimes; the vast numbers, strength and resources of the labor that contended under the leadership of the American Railway Union upon the one side of the Pullman palace Car Company and the General Managers' Association upon the other; the attitude of labor toward capital, disclosed in its readiness to strike sympathetically; the determination of capital to crush the strike rather than to accept any peaceable solution through conciliation, arbitration, or otherwise; the certainty with which vast strikes let loose the disreputable to burn, plunder, and even murder; the conversion of industrious and law-abiding men into idlers, lawbreakers, or associates of criminals; the want brought to many innocent families; the transformation of railroad yards, tracks and stations, as well as the busy marts of trade, into armed camps; the possibilities of future strikes on more extended lines of union against even greater combinations of capital—are all factors bearing upon the present industrial situation which need to be thoroughly understood by the people and to be wisely and prudently treated by the government."

As to causes of the strike they are found in the existence of the organization named, in the conduct of the Pullman Car Company toward its employés, and in the unwise action of the American Railway Union in admitting the workmen of the Pullman car shops into the organization. The leaders of the association at first opposed the strike, but found themselves, under the principles of the union, obliged to sustain it when once begun by Pullman workmen whom they could no longer restrain from their purpose.

The Pullman Car Company does not occupy an enviable position in this report. The deposits in the Pullman loan and

savings bank (substantially those of the workmen, half of whose accounts were under $100, and five-sixths under $500) diminished nearly one-half from July 1, 1893, to August, 1894. "These figures show how seriously the cutting down of wages ate into savings."

"As the result of the Pullman system and its growth, when the depression of 1893 came, morally calling for mutual concessions as to wages, rents, etc., we find on the one side a very wealthy and unyielding corporation, and upon the other a multitude of employés of comparatively excellent character and skill, but without local attachments or any interested responsibility in the town, its business, tenements, or surroundings. The conditions created at Pullman enable the management at all times to assert with great vigor its assumed right to fix wages and rents absolutely, and to repress that sort of independence which leads to labor organizations and their attempts at mediation, arbitration, strikes, etc."

The report regards the Pullman car company as "behind the age" in its hostility "to the idea of conferring with organized labor in the settlement of differences arising between it and its employés. The company does not recognize that labor organizations have any place or necessity in Pullman, where the company fixes wages and rents, and refuses to treat with labor organizations. The laborer can work or quit on the terms offered; that is the limit of his rights. To join a labor organization in order to secure the protection of union against wrongs, real or imaginary, is overstepping the limit and arouses hostility. This position secures all the advantages of the concentration of capital, ability, power, and control for the company in its labor dealings, and deprives the employés of any such advantage or protection as a labor union might afford.

"The strike was of the kind known as sympathetic." The railway employés engaged in it had no grievance of their own, but sacrificed themselves to the support of the principle of "solidarity of labor." The boycott of the Pullman cars would have been an "incongruous step for the remedy of complaints of railway employés." It risked the integrity of the association in an unwise and unnecessary way. It provoked the antagonism of all the railway lines, placing the latter in a position where they must either violate contracts and incur penalties, or oppose the misdirected effort to aid the workmen at Pullman in their conflict with the company.

"To preserve the integrity of associations designed to unite and organize labor on such a broad basis as that of the American railway union but two courses seem open: (1) To take a position against all strikes, except as a last resort for unbearable grievances, and to seek the more rational methods of conciliation and arbitration. To this object the power of public opinion would lend aid to an extent not now appreciated. (2) Conservative leadership, legal status, and the education of members in governmental matters, with the principle in view that in this country nothing can accomplish permanent protection and final redress of wrongs of labor as an entirety except conservative progress, lawful conduct, and wise laws enacted and sustained by the public opinion of its rulers—the people."

As to the General Managers' Association, this strike first exhibited its strength in opposing an organized attempt to obstruct traffic, and its energy and ability were conspicuous during the struggle. Prior to this event its attention had been almost wholly directed to "questions concerning transportation centering at Chicago in which the roads had a common interest. It thus determined the policy and practically fixed the relations of all the roads toward the public, as to switching, car service, loading and unloading cars, weights of live stock, rates, etc., and sustained each road in maintaining the position of the association as to these matters." No question has been made of the usefulness of the association both to the roads themselves and to the public. That it was forced into a conflict with its employés in the Chicago strike is not denied. Its vigor in meeting the attempt to coerce the roads into abandoning the use of Pullman cars is acknowledged. The justice of its course

must be conceded. At the same time it is seen that peaceful settlement of labor questions is not to be expected when great corporations like the Pullman car company maintain the attitude toward workmen displayed in the evidence on which this report is based. Such an attitude is so arbitary and exasperating as to make strikes inevitable, if not justifiable. It is not in human nature to submit patiently under such provocation, and it is foolish to expect.

INDEX TO LEADING ARTICLES

The journals quoted are indicated by initials, and their full titles are given in the opening pages of the Review. Other abbreviations are, Ill=Illustrated; W=Words.

25590. The Liability of Labor Unions for Damages—The Lucke Case. R. W. Raymond (E M J-Sept. 29.) 500 w.

25591. Bimetallism vs. Silver Monometallism (E M J-Sept. 29.) 1500 w.

25618. Governor McKinley Compares the New and the Old Tariff Laws (B I S-Oct. 23.) 1500 w.

†25963. The Work of the Beer Money. John Rae (C R-Oct.) 12000 w.

*26656. Silver Coinage Historically Considered.—A Masterful Review of Facts and Principles. Henry Downing MacLeod (E Mag-Jan.) 3000 w.

*26709. A Ship-Yard Foreman on Trades Unions and Labor Troubles (Eng L-Nov. 2.) 1200 w.

*26720. Depression in 1847 and 1894 Compared (B M-Nov.) 3300 w.

*26721. The Volume of Currency and Prices (B M-Nov.) 2300 w.

26764. The Wages of Employés. Editorial (R A-Nov. 9.) 1100 w.

26782. Cornering Gold. Editorial (M I T-Nov. 8.) 600 w.

26799. New York City's Magnificent Commerce (Sea-Nov. 15.) 3000 w.

26800. A Coöperative Contract System. John Richards (A M-Nov. 15.) 4200 w.

†26829. The Monometalist Creed. Henry Dunning MacLeod (N C-Nov.) 5800 w.

*26840. Building Land in Scotland (A L-Nov. 2.) 1800 w.

26849. Convicts on the Public Roads. Professor Holmes Gives the Workings of this System in North Carolina (M R-Nov. 16.) 3000 w.

26859. The Chicago Strike.—Report of the United States Strike Commission Appointed by the President July 26, 1894 (B J C-Nov. 17.) 5800 w.

.26873. The Brotherhood Suit Against the Reading, with Editorial (R G-Nov. 16.) 2800 w.

26913. An Open Letter.—To the Hon. Carroll D. Wright, the Hon. John D. Kernan and the Hon. Nicholas E. Worthington (R A-Nov. 16.) 2200 w.

26934. Prevention of Railway Strikes. James Peabody (R R-Nov. 17.) 2700 w.

†26950. Pseudo Individualism; or the Present Slavery. Arthur Withy (W R-Nov.) 6000 w.

27058. The Chicago Strike Report. R. W. R. (E M J-Nov. 24.) 1500 w.

*27103 Institutions and Economics. Editorial (I & I-Nov. 16.) 1600 w.

*27117. The Economic Development of Canada. (Abstract.) Charles Tupper (I & S-Nov. 17.) 2000 w.

*27145. Pullman and Paternalism. Charles H. Eaton (A J P-Dec.) 3300 w.

*27146. The Burden of Indiscriminate Immigration. Julia H. Twells (A J P-Dec.) 3000 w.

*27147. A Practical Example in Civics. Thomas W. Haskins (A J P-Dec.) 2500 w.

*27148 Dangers of Paternalism. G. F. Milton (A J P-Dec.) 3000 w.

*27149. A Labor Trust. E. M. Burchard (A J P-Dec.) 2400 w.

*27150. A Proposed Remedy for the Railroad Troubles. George Gary (A J P-Dec.) 1200 w.

†27216. Our Experiments in Financial Legislation. James H. Eckels (N A R-Dec.) 2800 w.

*27249 May a Man Conduct His Business as He Please? Carroll D. Wright (F-Dec.) 3000 w.

*27250. Stock-Sharing as a Preventive of Labor Troubles. Louis R. Ehrich (F-Dec.) 2200 w.

*27251. Is the West Discontented? A Local Study of Facts. J. H. Canfield (F-Dec.) 5000 w.

27299. A Dutch Coöperative Town (A A-Dec. 1) 1300 w.

*27321. Coöperative Engineering. Editorial (E-Nov. 23.) 2900 w.

*27391. The Cause of Panics. T. W. Graham (Mill-Nov.) 1800 w.

†27412. The Nature of Political Authority. Editorial (P S M-Dec.) 1200 w.

27425. Decision Against Brotherhood Employees on the Reading (R G-Dec. 7.) 3200 w.

27445. John Burns' Visit. Editorial (A & B-Dec. 8.) 1000 w.

We supply copies of these articles. See introductory.

MARINE ENGINEERING

The Training of Marine Engineers.

EVERYWHERE that civilization has advanced to the adoption of machinery as a substitute for manual labor, the subject of education holds a prominent place as a factor in industrial progress. Even in Japan, the latest and most wonderful example of national development, education is regarded as a *sine qua non* by its intelligent and able government. By educating officers and engineers, her smaller area and comparatively smaller population has been made more than a match for the Chinese hordes, and by her recent military exploits she has won a most influential and enviable position among oriental powers.

The Institute of Marine Engineers (England), having addressed a letter to the Board of Trade "advocating certain changes from present rules in the training of marine engineers," the board referred the subject back to that body and to other societies for advice. Thereupon the Institute of Marine Engineering adopted the following resolution:

"That in the opinion of this meeting, it is highly necessary to amend the present regulations as to second-class certificates for engineers with regard to service in the workshop, where the minimum service should be five years; and that the attention of the Board of Trade should be called to the desirability of creating a third-grade certificate, which should be granted to those who have served at least five years in an engineering work, and one year at sea, and passed the prescribed examination."

The following argument also accompanied the resolution: "Greater and increasing responsibilities rest on the engineers of to day as compared with those of the past. Foreign competition is greater and increasing, and it rests largely with the most intelligent use of material in the engine department to gain the advantage in the competition. There is less hand and more machine tool labor in our workshops now than formerly, and, therefore, the more reason for an extended apprenticeship. In our large steamers there are many young engineers who sail for years in a capacity junior to fourth engineer, and who have no opportunity for passing the examination for second engineer, but who might have granted them an opportunity of obtaining a third-grade certificate as a means of encouragement."

This resolution and the remarks accompanying it, as presented to the Board of Trade, are printed and made the source of editorial comment in *Engineering* (London, Nov. 16) which remarks that "the questions at issue in regard to a longer period of workshop experience for marine engineers are so various that it is difficult to know from what point to approach the subject.

"Undoubtedly it is desirable that our sea-going engineers should have a thorough practical knowledge of the engines under their charge; but that a theoretical or scientific knowledge of marine engineering is necessary for sea service, *i. e.*, service afloat, is a matter which is evidently considered by some to admit of discussion. No doubt in order to be a good marine engine designer, it is highly desirable that a man should have had experience of the working of marine engines in actual use. That is the other side of the question, but engineers afloat are not required to design engines."

If the standard of qualification be raised too high it is thought the supply may easily become too small to meet the demand for qualified engineers, a result that could hardly be more than temporary, yet one which it seems to be feared by *Engineering* would become a protracted embarrassment. It cannot of course be the purpose of any one to advocate a standard which will be prohibitive, and within reasonable limits, if the demand for qualified men prove greater than the sup-

ply, such an increase of pay would inevitably result in attracting more men to this calling in life, and an adjustment of supply to demand would follow in due course.

As to what may be gained by an extra two years spent in the machine shop, it is quite doubtful that such improvement in the qualifications of marine engineers would result as seems to be expected by the Institute of Marine Engineers. If the two years were occupied in work requiring the use of such tools and methods as marine engineers must employ on shipboard, some good might accrue from added experience and skill. In the shop, however, machine tools and other methods are the rule, and it is difficult to see how the desired improvement would be gained. It is very pertinently argued that "the engineering factories of the country are not run as educational establishments, and where the man is found to be most useful for forwarding work, there he will be put, even if he learns but the one job. Even articled pupils, with whom a stiff premium has been received, are apt to find difficulty in getting sufficient variety of work—much more so the class from which sea-going engineers are likely to be drawn."

The resolution originally adopted by the Institute of Marine Engineers was also referred by the Board of Trade to the North-east Coast Institution of Engineers and Ship Builders, and Mr. J. R. Fothergill was invited by the council of this institution to contribute a paper on the subject. Of this gentleman's qualifications for the discussion of the question, we are informed that "he has himself had large experience as a marine engineer, and has held important appointments as superintending engineer." Mr. Fothergill in his paper, among much other valuable suggestion, urged that "the present regulations of the Board of Trade met all requirements at the time when they were drawn up; but the march of progress has been rapid and the necessities of the case demand thorough, practical and technical knowledge; yet he asks does this demand upon the educational capabilities of a sea-going engineer require more than technical knowledge, namely, a useful knowledge of the principles that govern the general working of the machinery under his charge?" It is acknowledged that this is a difficult question to answer, and that the precise lines on which the education of marine engineers should proceed are difficult to define. As to the time spent in shop experience, it seemed to be the consensus of opinion expressed by those who discussed Mr. Fothergill's paper at the meeting when it was presented, that five years is the minimum that should be required. The proposition to grant third-class certificates was also much favored. Its intent and effect would be "to create a position and a status to many who have to wait long for promotion."

"An assistant engineer is not eligible for a second-class certificate until he has been twelve months in charge of a watch, and in large mail steamers he may have to wait years for his opportunity; whereas a younger and less experienced man may join a smaller vessel in which there are only three engineers, so that after but twelve months' experience he may become eligible for the second-class certificate.

"Mr. Fothergill did not propose that the third-class certificate should be compulsory to all engineers, but that in all foreign-going steamers carrying four or more engineers, or in all steamers of 300 horse-power nominal and upwards, the third engineer should hold a certificate. He suggests that the third-class certificates should be granted on examination after one year's sea service, and it is also proposed that the period of sea service for a second-class certificate should be altered from one to two years. These recommendations will, we think, be accepted as sound by most persons who have had actual experience in these matters. It is also proposed that the fact that an engineer should 'have served at least four years at sea in the engine-room as an engineer on regular watch in the foreign, home or coasting trade,' should not—as in accordance with the present Board of Trade regulations—entitle him to become a candidate for a second-class certificate."

As a result of Mr. Fothergill's paper and the discussion it elicited, resolutions were adopted, recommending to the Board of Trade, the granting of third-class certificates (not however, to be made compulsory to all engineers); that on foreign-going steamships of 300 nominal horse-power and upwards, the third engineer shall be a certificated engineer; that each candidate for third-class certificates shall have served twelve months at sea; that each candidate for a second-class certificate shall have served two years at sea, and that clause 3, par. 35, in the present Board of Trade regulations (which entitle an engineer after having served four years at sea in the engine-room as an engineer on regular watch in the foreign, home, or coasting trade, to become a candidate for a second class certificate) be annulled.

Breakdowns of Steamer's Machinery.

A LONG list of accidents to marine engines and machinery on ships, compiled from newspaper reports, confessedly incomplete, and also unclassified, is given by a writer in *Fairplay*, Nov. 9. The list covers a period of twenty months beginning with January, 1893, giving the names of vessels, and in most cases the nature of the injury; though only the names of vessels whose machinery was disabled (without stating the nature of the disability) are given in quite a number of instances. The variety of accidents to which steam machinery for marine use is liable, is, however, well displayed in this compilation, and a comparison of the number of accidents of each kind with that of others will fairly show which are the most frequent.

Thus out of a total of 129 disabilities, the particular nature of 106 are named. In a few cases, two of these disabilities occurred simultaneously on the same ship, and in the most of the cases classified below the ships were so much disabled as to compel them either to put in, or be towed into the nearest available port. We have arranged these in groups from the general list as given.

The list includes 43 broken shafts; 31 broken or lost propellers; 7 broken, cracked, or otherwise injured cylinders; 2 boilers burst, and 5 leaky; 4 broken crankpins, 3 broken crank arms, 3 broken down pumps and one condenser; 1 leaking steam pipe; 1 burst steam pipe; broken eccentric rod, eccentric, piston rod, connecting rod, and crown wheel, of each 1; 2 pistons broken; 1 rudder post broken; 1 steering gear broken down; 1 furnace disabled; 2 feed pipes disabled; 23 the nature of whose disability is not named.

The most frequent breakage is that of shafts. Next in order are propeller breakdowns and cylinders. The steam generating apparatus makes a very favorable comparison with the engines and propeller machinery, though in the popular mind the former is looked upon as the most frequent source of accident. The frequency with which shafts break down seems to prove either that their manufacture has not been brought to a desirable degree of perfection, or that their designers too frequently fail to give them the proper size needed to meet all the strains to which they are to be subjected.

Surface of Thrust Blocks.

A USEFUL diagram with accompanying explanation, by Geo. R. Bate, Assoc. M. Inst. C. E., is presented in the *Practical Engineer* for Nov. 2. "In its construction the effective horse-power, or the power actually employed in propelling the ship, has been assumed to be equal to two-thirds the indicated horse-power of the engines so that if

I.H.P. = the indicated horse-power of the engines

E.H.P. = effective horse-power = I.H.P. $\times$ $\frac{2}{3}$

K = speed of vessel in knots

T = total thrust, or load on thrust block in lbs.

P = pressure on thrust collars, lbs. per square inch

S = surface of thrust collar, square inches per I.H.P., then

$\frac{K \times 6080}{60} = K \times 101.3$ = speed in feet per minute,

and work done per minute in foot-pounds.

$= T \times K \times 101.3$,

so that $T \times K \times 101.3 = E.H.P. \times 33000$;

therefore $T = \frac{E.H.P. \times 33000}{K \times 101.3}$.

Again, if $E.H.P. = \frac{2}{3}$ I.H.P.,

we may write $T = \frac{2\ I.H.P. \times 33000}{3\ K \times 101.3}$

$= \frac{I.H.P. \times 22000}{K \times 101.3} = \frac{I.H.P. \times 217}{K}$;

therefore S, the surface of thrust collars in square inches per I.H.P.,

$= \frac{217}{K \times P}$.

"The diagram gives the value of S with P, varying from 30 lbs. to 80 lbs. per square inch. In ordinary practice this pressure is 50 lbs. to 60 lbs. per square inch in naval work, and 40 lbs. to 50 lbs. per square inch in mercantile steamers, although in cases where white metal is fitted, it is found that these loads may be safely increased by 25 per cent.

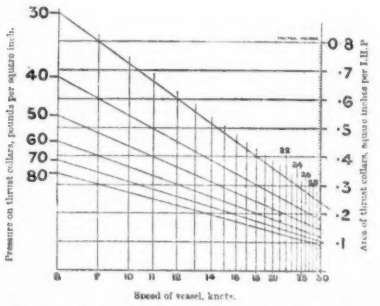


Diagram giving thrust surface per I.H.P for speeds of vessels up to 30 knots at various pressures between faces.

"As an example, let us suppose a case of a thrust block for a vessel having engines of 3000 I.H.P. driving her at a speed of 18 knots, and we require to determine the necessary surface of thrust collars, that the pressure on them may not exceed 60 lbs. per square inch. At the point marked 18 knots on the scale for speed of vessel, follow the ordinate up until it cuts the line marked 60 on the scale of pressures on thrust collars to the left of the diagram, at which point of intersection follow to the right, and read off the corresponding surface of collars per I.H.P.—*i.e.*, 0.201 square inches; then $0.201 \times 3000 = 603$ square inches, the total thrust surface required for $E.H.P. = 3000 \times \frac{2}{3} = 200$

and $\frac{2000 \times 33000}{18 \times 101.3} = T$,

the load on the block = 36180 lbs.; then, if pressure per square inch between surfaces is not to exceed 60 lbs., we have total surface of block

$= \frac{36180}{60} = 603$, as by the diagram."

Economy of Triple Screws.

THE second meeting of the Society of Naval Architects and Marine Engineers was held on the 16th Nov. at the auditorium of the Am. Soc. of Mechanical Engineers, and its proceedings comprise a great deal of good work. A report of the meeting was printed in *American Machinist*, Nov. 22.

Passing over the able address of Presi- C. A. Griscom, the subject of greatest importance presented at the meeting seems to be the economy of triple screws, discussed by Commodore George W. Melville, Engineer-in Chief, U. S. N., who claims the honor of recommending the use of this system of propulsion on the new U. S. cruisers *Columbia* and *Minneapolis*. The system, however, was not new when thus urged upon the consideration of the Navy Department.

"Although I had the honor of recommending the use of triple screws on these vessels, it is hardly necessary to tell this society that the use of triple screws was not a novelty, and that any credit in the matter arises simply from their use for machinery of much greater power than had previously been attempted, and for persisting in the design against the advice of some of my best friends in the profession, who believed it too much of an experiment.

"When I was asked to design machinery of about 21,000 I. H. P. for the *Columbia*, there were a number of questions which came up for consideration. One was that of securing economy at moderate speeds when full speed was so high, and another was that of the shafting. When the design was under consideration no steel shaft had yet been made in this country for the transmission of so great a power

as 10,000 horses, and while I had every confidence in my friend, John Fritz and the Bethlehem Iron Company, I felt that it would be safer to adopt a design which would give us smaller shafting. The alternative to triple screws was twin screws, either with one very large engine, or two smaller ones on each shaft; the former meant large parts of the machinery all through, and the latter great multiplication of parts."

A speed of 22 knots per hour with 21,000 I. H. P. was all that was hoped for with these vessels, and no increase of economy in propulsion was expected; but on trial the *Columbia* made 22.8 knots per hour on 18,500 I. H. P. thus demonstrating the wisdom of Commodore Melville's recommendation, and a further gratifying fact is that a gain in economy has been reached at maximum power. Although this system has thus far only been tried with warships it is not likely to stop there. Commodore Melville thinks that the arrangement of screws commends itself for all very high speed ships, and says "if it were not dangerous to prophesy, I should be prepared to anticipate the adoption of triple screws for all the new 'flyers' that enter for the transatlantic race."

The cause of the increase of economy at maximum powers will excite inquiry. To account for it, it is explained that "the most reasonable explanation of the increased economy of propulsion is that, in an unusual degree, the center screw, which occupies the same position as the propeller in single screw vessels, profits by the forward motion of the frictional wake, and this without interfering with the stream line motion sufficiently to increase the vessel's resistance." To some of the fossil remains of a former age in marine propulsion, present at the meeting of the society, this explanation did not seem altogether satisfactory.

INDEX TO LEADING ARTICLES.

The journals quoted are indicated by initials, and their full titles are given in the opening pages of the Review. Other abbreviations are, Ill=Illustrated; W=Words.

*26681. Address of the President, Thomas Sutherland, before the Institute of Marine Engineers (M E-Nov. 1.) 4000 w.

*26717. Steam Pipe Explosions on Ship Board (E-Nov. 2.) 3300 w.

26729. The New Launch for the Cornell University Crew. Ill. J. C. McMynn (E E-Nov.) 700 w.

*26735. Surface of Thrust Blocks. George R. Bate (P Eng-Nov. 2.) 200 w.

26798. The St. Louis Successfully Launched (Sea-Nov. 15.) 3000 w.

26825. The Proposed United States Torpedo Boats, with Editorial. Ill. (Ir Age-Nov. 15.) 3800 w.

*26977. Breaksdown of Steamer's Machinery (F'y-Nov. 9.) 2000 w.

27009. Hydraulic Steering Gear on the U. S.S. "Olympia." Ill. (Ir Age-Nov. 22.) 2000 w.

*27013. The Free Port of Copenhagen. Ill. (Tr-Nov. 9.) 3500 w.

27023. Hydraulic Power for Warships. (Abstract.) Albert W. Stahl (E N-Nov. 22.) 3500 w.

27024. Torpedo Launch for the U. S. Battleship "Maine." Ill. (E N-Nov. 22.) 1600 w.

27026. Second Annual Meeting of the American Society of Naval Architects and Marine Engineers, with Review of Leading Papers (A M-Nov. 22) 5000 w.

*27040. The Proposed Cardiff Harbor Trust and South Wales Dock Extension. Ill. (Eng L-Nov. 16.) 4000 w.

*27089. The Training of Marine Engineers. Editorial (E-Nov. 16.) 3800 w.

*27185. Rules, etc., for Designing Screw Propellers. Ill. M. J. K. (M W-Nov. 23.) 500 w.

*27253. Aluminum Torpedo Boats and Other Vessels (Inv-Nov. 24.) 1200 w.

27405. An Improved Sail System. Ill. H. C. Vogt (Sc A S-Dec. 8.) 1800 w.

Serials.

16636. Marine Engine Design (M W-Began Oct. 6, 1893—17 parts to date—30 cts. each).

21969. The Shark and the Sailor. Ill. A. Ewbank (I E-Began April 14, 1894—22 parts to date—45 cts. each).

26091. Some Points in Modern Marine Engine Practice (I & I-Began Oct. 12—7 parts to date—30 cts. each).

26182. Development and Construction of the Marine Boiler (M W-Began Oct. 19—2 parts to date—30 cts. each).

27100. The Manning of Sailing Vessels. By a Skipper (F'y-Began Nov. 16—1 part to date—30 cts).

27378. Water-Tube Boilers and Their Application to War Vessels. Ill. J. Nastoupil (A E R J-Began Dec.—1 part to date—30 cts).

We supply copies of these articles. See introductory.

MECHANICAL ENGINEERING

Losses in Boiler Practice.

IN a paper read before the Engineers' Society of Western Pennsylvania, Nov. 15, and printed in the *American Manufacturer*, Nov. 23, Mr. Daniel Ashworth does not deem it necessary to enter upon a purely technical discussion but prefers to adopt a more popular style of treatment.

The effort is "to make the story so simple that every one, not necessarily an engineer or a technical scholar, can grasp it instantly," yet without depreciation of the importance of a thorough knowledge of technical principles. The proposition is made that the greater losses in boiler practice are directly chargeable to lack of intelligence and proper management in the boiler room.

"The development of boilers, together with furnaces and devices, all converging to a more thorough combustion and rapid steam generation, would certainly lead one to believe that a radical improvement in the way of economy of fuel would result. While, in a measure, in special cases and conditions, there has been some improvement, yet a careful review constrains us to believe that the results are far short of what would be expected, and this is demonstrated, not only by careful and elaborate tests, but, in addition, by close observations of regular, continuous operation."

Seeking for an explanation, it is found in the aggregation of small losses, which neutralizes the otherwise beneficial effect of improved appliances for steam generation. Furnace walls cracked and admitting streams of cold air, indifference to the necessity of keeping boilers clean inside and out, and lack of capacity in those placed in charge of boilers are among the sources of loss. Irregular and injudicious supply of fuel and water are also frequent faults. Gradual increase of demand for steam power often leads to over-taxed boilers always resulting in reduced economy.

As to power plants in city buildings a great fault is want of space. The boilers are thereby rendered difficult of access for inspection and cleaning; and the result is that these necessary functions are either performed in a perfunctory manner or are put off as long as possible, instead of being attended to regularly and systematically. It is pertinently queried "how could it be expected that boilers and furnaces could be kept in anything like proper order where every part is of such difficult access?"

"The revival of mechanical stokers, which have been lying dormant on the other side of the ocean for a number of years, has resulted in the development of a number of machines, each possessing its respective merits, not only as regards the machine itself, but in the type of furnaces that form a part of the same. But taken as a whole, the expectations of the most earnest advocates of these machines have not been realized, and the inherent weakness or defect which presents itself in the greater number of them is the large amount of incandescent fuel that is dropped into the ashpit during the process of dumping the bars, which is necessary at frequent intervals. This entails not only a loss of the very best fuel in the condition to produce the best results, but also wastes in the critical operation, a large volume of heat that should be retained and distributed to do effective work. The most earnest advocates of mechanical stokers recognize this, and it has become a matter of serious thought in considering this loss whether we are really better off than with first class hand firing or with a shaking grate. That there is room for radical improvement in this direction is beyond all question. Dispensing with the dumping process, carrying with it great masses of rich fuel, would be heartily appreciated by those who are earnest advocates of the stoking principle."

As to securing a higher grade of intelligence in persons placed in charge of boiler rooms and their numerous appurtenances,

the effort to do this is not made because intelligence costs more in point of wages than ignorance. It does not follow that ignorance is the cheaper purchase. Were this the case the same line of argument would prove that "it would be more profitable to have ignorance and its attendant waste surrounding us on every hand. If proprietors and progressive superintendents are willing, and I believe they all are, in general, to adopt mechanical devices when it is clearly demonstrated to them that their operation is such as is conducive to economy, and when they cheerfully place upon their plants, automatic dampers, shaking grates, water alarms, and such appliances, does it not seem to be a gross inconsistency that they halt, or hesitate, at least upon the question of a little investment for more brains and intelligence?"

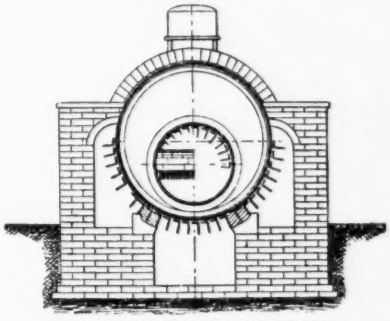
Evaporative Test of a Cornish Boiler.

THE particular test here referred to was made with a Cornish boiler fitted with heat conducting web plates, the object being to obtain experimental evidence as to the effect of extending heat absorbing surface on the side exposed to flame and hot gases, thus increasing the surface receiving heat materially over that imparting it to the inclosed water. The results were expected to give a more or less conclusive answer to the proposition that heat is much more rapidly taken by water from a given surface on the interior of a boiler than it is on the average, imparted by the gases of combustion to an equal extent of surface on the exterior. The test is described in *The Practical Engineer* (Nov. 16) by Michael Longridge, M. A.

The subject of the experiment was, "a Cornish boiler, 15 feet long by 5 feet 6 inches diameter, with one internal flue 2 feet 9 inches diameter. Both flue and shell were made up of six rings of plate. Upon these rings were riveted angle irons. The metallic surface in contact with the gases was increased by these angle irons from 256 square feet, which would have been the heating surface of the boiler had the angle irons been absent, to 772 square feet.

"The boiler was set in brickwork, and was covered on the top with ¾ inch of sand, one layer of bricks on edge 4½ inches thick, and about 2 inches of composition, which was still wet when the trials were made. The brickwork and covering were exposed to the wind, the boiler being out of doors in a yard without any roof. The chimney was 33 feet high and 12 inches square at the top.

"The fire-grate consisted of 19 grate bars about 1⅛ inches wide by 3 feet long, and of a dead plate 14 inches long, pierced with twelve holes 1 inch diameter, for admission of air. The fire-door and furnace front were pierced with thirty-one holes, having an aggregate area of 6.6 square inches; and in addition there were two air conduits, one on each side of the fire-door, each of which had an area of 10



CORNISH BOILER WITH RING PLATES.

square inches. The gases, after leaving the internal flue, passed under the boiler, and returned by side flues to the chimney. The boiler was cleaned and the flues swept about a fortnight before the trials."

Notwithstanding this large increase of heat absorbing surface it is stated that very little, if any, increase of evaporative power was realized; and as the advantage of extension of surface on what are known as the *Serve* tubes seems quite authoritatively established, a question arises as to what condition exists in the test under consideration that does not obtain in boilers with Serve tubes. The answer is found in the want of molecular continuity between the angle irons riveted to the plates of the Cornish boiler and the plates themselves. It is impossible to bring these irons into anything like such continuity by

riveting them on, and this lack must certainly and greatly interfere with the conduction of heat from the riveted-on surface to and through the boiler plates. It is to be regretted that the evaporative capacity and efficiency of this boiler had not been determined before the angle iron extensions were riveted on, so that the exact measure of increase of evaporative power, if any, could have been determined. The position of the angle irons riveted on the shell is well illustrated in the cut, as also their arrangement in the flue. Probably most engineers will, on inspection, fail to see in the arrangement much analogy to the *Serve* tube boilers, and would in advance expect just such a negative result as was obtained in the test. It would not be a matter of much surprise to learn that the result of such a test showed even diminished efficiency as compared with the original boiler.

The Economics of Lubrication.

THE existing variety of opinion and action in the use of lubricants, is noted by way of introduction to an editorial on the subject of lubricants in the *Railway Gazette*. This is more particularly treated with reference to locomotive practice, but the "economics of lubrication" extends to all fields of mechanical industry; the faults in practice found in any one of these are those which may be looked for in any of the others. Since these faults do not generally originate either in the lubricants themselves, or in the constructions to which they are applied, but in human defects, among which ignorance and carelessness are included, and as remedies for existing faults must deal principally with the human side of the question, remarks pertinent to these as met with in any department of mechanical engineering are necessarily general in import and application.

As to the quality of lubricating materials, experience has shown that the best, even though high-priced, are the least expensive in the long run, or would be so if applied economically. The wastes in lubrication are, however, enormous in practice, and there is no justification or valid excuse for the fact. "Every man should be well drilled in the use of lubricating material." Of course proper provision for economical lubrication should be supplied in all machine construction.

"Aside from good mechanical condition of the parts to be lubricated, we should of course have the best form of oil cups and feeders, so that the flow will be regular but only as fast as the service requires. There are many forms of these, especially for locomotives, which will do their work properly if well cared for. All oil packing receptacles like journal boxes should be tight and protected by proper covers and guards, so that there shall be the least loss of material and the least influx of dust and dirt."

But when the best appliances and the best lubricants obtainable are provided, only the possibility of economical lubrication exists; the probability of wasteful use is to be considered from the human standpoint. It is natural for the average man to be wasteful in the use of what costs him nothing. The morality of economy, as a principle of action in all things, has rarely a place in the education of workmen.

"The amount of material used by one man in doing certain work may be 50 per cent. more than that expended by another under about the same conditions. Many of the bearing surfaces on locomotives have to be oiled by hand, so that there is a great chance for relative saving or loss under this head. A constant supervision on the part of competent inspectors is necessary (no matter what their position is called), to see that all concerned are using the best methods to get good results. As a rule, those who are zealous in the service welcome suggestions, while those who object are usually persons with whom there is need of reform. The work of the car-oilers, in packing and oiling at stations, of trainmen with hot boxes on the road, and the work of individual enginemen with their engines, must all be carefully watched until the practice is uniform and efficient, and then it has to be kept so. The inauguration of this class of systematic inspection, has resulted more than

once, under our own observation, in nearly doubling the mileage of a certain amount of oil on both engines and cars. One valuable feature in testing special oils has often been to show the managing officers how far the work done by the oil originally in use could be extended by careful watching and drill of the men, without causing delays from poor lubrication."

The enforcement of discipline in the matter of lubrication is no easy task in any extensive establishment. "It is easier to get good lubricating material at economical prices than to get good men who will regularly practice economy with material which some one else pays for." The only adequate remedy for this will be the cultivation of the sentiment among workmen, that careless or wanton waste is on a par with careless statement of facts or willful and gratuitous falsification, and that these vices are equally dishonorable and degrading to the man who indulges in them.

A Convenient Degree Scale.

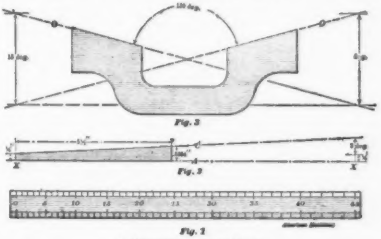
MR. FRANCIS W. CLOUGH, has contributed to *American Machinist* a drawing of a very handy device which he has used as a substitute for a protractor and which he regards as much more convenient and accurate than any protractor or graduated Tee-square. This appears to be a real improvement. Mr. Clough is known to us as a man of such good mechanical judgment as to render valuable his opinion based, as he asserts, upon an experience of a number of years with the device in question. We herewith reproduce the drawing and an abstract of the descriptive text.

"Figure 1 represents the top of scale, showing the graduation; at the right is an end view; the length between the extreme or end lines is just 12 inches; a margin is left at each end of scale for protection of end lines.

"The graduations increase in each division from zero to 45 degrees, more perceptibly in the higher numbers than among the smaller number of degrees. The principle involved in its use is that with a 12-inch radius (24-inch diameter) measurement of angles to a greater accuracy can be obtained than with one ¼ or ⅓ that size, and yet the scale is far less bulky than a 24-inch diameter protractor. It is a well-known fact that certain angles can be quite readily obtained by measurement. As for example, a 45 degree line from a given point is quickly obtained by drawing two lines of equal length at right angles to each other, and joining the ends by a line. If one degree can be obtained by measurement, so any other degree in the circle may be as readily obtained if the proper measuring scale is at hand and understood.

"The method of using the scale is simply to measure off, say a horizontal line (though it may be a vertical line or oblique line) the length between the two end lines on scale = 12 inches; from that measure a vertical line from zero, the number of degrees desired, and connect the points by the oblique line.

"Figure 2 illustrates laying out a wedge



A CONVENIENT DEGREE SCALE.

5½ inches long, ¼ inch thick at point end, having a taper of 3 degrees, amounting to ⅝ inch in 1 foot. The line *A* from *X* to *X* is 12 inches long; measure upon vertical line ¼ inch, the thickness of point of wedge; measure from the ¼ inch 3 degrees per scale, and join ends by a connecting line *C*, and we have a wedge 3 degrees taper.

"Figure 3 illustrates further use of the scale. The lines *O O* make an angle of 15 degrees with the horizontal line; a recess is left in center of the figure. Now, to draw such a figure in outline, we may assume that the lines *O O* form an angle of 150 degrees, each 75 degrees from a vertical line, or 15 degrees from a horizontal line; the result would be all the same, and as easily obtained by the scale. I have had occasions to use this scale where a

measurement of an angle was wanted with greater accuracy than could be obtained with the ordinary protractor.

"I am not, however, without protractors, graduated steel square and other means to obtain angles, and ordinarily use them, but this scale gets there closer than any of them when required. I can assure you it is a neat job to graduate one, and if the maker has only a two-foot rule and scratch awl at hand, he had better postpone the attempt."

Mr. Clough says that in graduating this scale he used a generating circle of 57.3248 inches in diameter. If, however, such scales came into general demand, it seems quite possible to construct a graduating engine that would do the work as accurately and cheaply as the graduation of other scales is now done, so that a scale of this kind could be afforded at a reasonable price.

Areas of Contact Between Wheels and Rails.

IN this department for November we reviewed two papers bearing upon the subject of areas of contact between balls and cylinders pressed against resisting plane surfaces. It seems that for some reason, considerable attention is at present directed to this subject in different quarters. The latest utterance we have seen is a communication from Mr. J. B. Johnson, to the American Society of Civil Engineers, printed in their September proceedings and reprinted in the *Railway Review*, Nov. 17. It includes a great number of diagrams giving outlines of areas of contact obtained by experiments performed five years ago.

"A section of a steel-rimmed locomotive driver 44 inches diameter and a section of a 33 inches diameter cast-iron car wheel were procured and mounted in a 100,000 pounds Riehle testing machine. Short sections of steel and iron rails were also procured and placed in the machine, so that the wheel treads rested upon them in a normal position. They were then loaded with 5000 pounds increments, from 5000 to 60,000 pounds, the area of contact being measured after each loading. The surfaces of the wheel treads and also of the tops of the rails were highly polished, so as to become good mirrors, before the experiments were made.

"The areas were obtained by marking with wet chalk the surface of the rail and rubbing it down, with a moistened finger and allowing it to dry. This gave a whitish appearance to the surface, with no appreciable thickness of film, and the actual area of pressure contact was clearly shown by a slight discoloration of this surface. A pencil line was passed around the border of this contact area, and then the area copied on tracing paper. The surface was then cleansed and examined for permanent distortion, and prepared for another loading. No permanent distortion was noted upon either rails or wheels at the contact surface up to the 60,000 pounds limit. At this loading, however, the web of the rail was observed to take a permanent set."

The plottings of areas obtained with different pressures strongly indicate that the areas vary directly as the pressures; or, as Mr. Johnson states it, "the load divided by the area of contact, or the average stress per square inch over the area of contact is a constant for all loads." He finds this constant to be about 80,000 pounds per square inch, "but the distortion or compression of the surface at the center of these areas of contact is just twice the average distortion over the area, and since the loads seem to be within the elastic limit of the material, it follows that the intensity of stress at the centers of these areas of contact was twice the average intensity of some 80,000 pounds for the steel driver upon a steel rail, or the maximum intensity of stress at the centers of these areas was for steel upon steel 160,000 pounds per square inch. For the chilled cast-iron wheel 33 inches in diameter this maximum intensity was still greater as the area was less. These areas were obtained by placing two cylinders in contact their axes being at right angles."

Mr. Johnson, in closing the communication, expresses the view that the analysis of these two cases, namely a cylinder upon a plane, and a sphere upon a plane, considering the stress distributed over the areas of contact according to the laws of

the parabola and of the paraboloid, with due allowance for the distribution of the stress through the body of the roller, according to the laws already determined by Professor Marston, would show a close agreement between the computed and the actual areas of contact, and would serve as the last word on this subject from the mathematical point of view.

Facts About Bolt-Making.

THE importance as well as the difficulties of getting stock for bolts made of the proper size, to gage, are illustrated by a narration of the experience of a certain firm of bolt manufacturers which forms an introduction to an article by B. F. Spalding in *The Age of Steel*. This concern, using annually over a hundred tons of half-inch round steel in the form of headed bolts whose threads are to be cut in bolt cutting machines, and from ½ to 6 inches long under the head, found the greatest obstacle to their success lay in the imperfect rolling of the iron. An amusing as well as instructive story is that of their inexperience up to the time when it merged into experience ripe enough for them to accept the advice of their superintendent and insist upon getting the stock made to a gage supplied by the latter. Manufacturers urged that it was not "practicable to roll iron any better, any rounder, or any nearer to the gage" than they were doing. The proprietors of the establishment referred to, bringing this statement before the superintendent, he replied:

"It is impracticable, perhaps, for the workmen to roll the iron properly and to the correct size in the rolls which they have to use and for the wages they receive; but if the mill owners will keep their rolls in repair, and pay the men by the day, it will be practicable enough to get iron perfectly round and accurate in dimensions. It is done in other countries. The iron we imported from England was round, and if you will look at the sample bolts which those bolt manufacturers sent, you will see that the iron they are made from is both round and of the right size. He went out into the blacksmith shop, and soon returned with a handful of short pieces of round iron, which he laid before the proprietors. Now, said he, you can see for yourself whether you would be willing to accept that kind of stuff as a proper legal fulfilment of the specifications of your contract for round iron. It is not picked out, but is a fair sample just as the man is cutting it off now at the shears." After an examination of the specimens they were at last convinced that the superintendent supported the right end of the controversy, and by dint of sheer persistence they "have for the last ten years obtained their stock quite round and correct in size." The result has been a great economy in the cost of manufacture.

"Very great improvements have been made in cutting threads on bolts, and yet whether they are cut with old-fashioned tools, stocks and dies in the blacksmith vise, or with the latest improved solid die bolt-cutting machine, the cold fact still asserts itself that it is extra work to remove extra stock.

"It is not probable that many dies for cutting threads will cut so clear, clean and free, that they do not in some degree raise the thread. Even in cutting a V-thread in the lathe, with a single pointed tool, this effect is observed. One of the best authorities on lathe practice makes this remark: 'As the cutting edge of the threading tool becomes dulled (and this occurs in some degree from the first instant the tool is put in use), its action partakes of the nature of forcing, as well as that of simple cutting the metal, and this induces the tops of the threads to raise slightly above the diameter of the work."

A comparison between bolts made prior to 1864 and those made at the present time indicates a very great improvement. In the year named the special committee of the Franklin Institute presented their report on the question of a proper system of screw threads. The simplification to a uniform standard thus secured is only one of many benefits conferred up on the mechanical industries of the country by the action and influence of the Franklin Institute.

INDEX TO LEADING ARTICLES.

The journals quoted are indicated by initials, and their full titles are given in the opening pages of the Review. Other abbreviations are, Ill=Illustrated; W=Words.

The Machine Shop.

26801. Construction of the Logarithmic Spiral. Ill. J. G. A. Meyer (A M-Nov. 15.) 2000 w.

26803. A Convenient Degree Scale. Ill. Francis W. Clough (A M-Nov. 15.) 500 w.

26804. Some Modern Shop Practice. Ill. John T. Usher (A M-Nov. 15.) 1400 w.

*26812. Moulding Condensers. Ill. (M W-Nov. 9.) 1200 w.

26821. The Manufacture of Burglar-Proof Vaults. Ill. (Sc A-Nov. 17.) 900 w.

26822. Portable Stone Dressing Machines of the American Pneumatic Tool Company. Ill. (Sc A-Nov. 17.) 900 w.

27001. Segment Work in the Pattern Shop. Ill. John M. Richardson (A M-Nov. 22.) 1600 w.

27099. Facts About Bolt Making. B. F. Spalding (A S-Nov. 24.) 2500 w.

27261. Points About Turret Lathes. James Hartness (M A-Dec.) 2200 w.

Steam Engineering.

*26708. Steam on Common Roads. Editorial (Eng L-Nov. 2.) 1500 w.

*26831. Standards Employed in Engine Testing. R. C. Carpenter (S J E-Oct.) 6000 w.

*26885. Locomotive Valve Setting. Ill. F. F. Gaines (S J E-Nov.) 23 0 w.

*26886. Comparison of Efficiencies of Common and Ball-Bearing Jacks. Ill. T. F. Ahern (S J E-Nov.) 2000 w.

26908. The Economy of Small Anthracite Coal. George H. Ward (H & V-Nov. 15.) 2300 w.

26937. Instructions to Boiler Attendants (S V-Nov. 15.) 2800 w.

27003. Apparatus for Testing Steam Gauges. Ill. James F. Hobart (A M-Nov. 22.) 3300 w.

27039. How to Run Steam Boilers (Eng-Nov. 24) 2400 w.

27069. Losses in Boiler Practice and Some of Their Causes. Daniel Ashworth (A M & I W-Nov. 23) 3000 w.

27072. Setting Engine Valves. Ill. Thomas Hawley (B J C-Nov. 24.) 2800 w.

27073. Two Cylinder vs. Three-Cylinder Compound in Mill Work (B J C-Nov. 24.) 1200 w.

*27129. Evaporative Test of a Cornish Boiler Fitted With Heat-Conducting Web Plates. Ill. Michael Longridge (P Eng-Nov. 16.) 2000 w.

27165. Steam Engine Fly-Wheels. William R. Kales (A M-Nov. 29.) 700 w.

*27184. Meldrum's System of Forced Draught. Ill. (M W-Nov. 23.) 700 w.

27189. The Standard Automatic Safety Throttle Valve. Ill. (Ir Age-Nov. 29.) 1800 w.

27195. The Chilling Action of Feed Water. Ill. (S E-Nov.) 2400 w.

27197. Some Leaks About the Plant. George West (S E-Nov.) 2000 w.

27199. The Circulation of Water in Horizontal Tubular Boilers. Ill. Charles Desmond (S E-Nov.) 2800 w.

†27228. Description of an Improved Steam-Separator and an Improved Steam Jacket. Ill. Charles T. Porter (A S M E-Dec.) 2000 w.

†27235. Experiments on a System of Governing by Compression. John H. Barr (A S M E-Dec.) 3000 w.

27265. Why Some Engines Pound. W. H. Wakeman (M A-Dec.) 1200 w.

*27267. Practical Steam Engineering (Eng L-Nov. 23.) 2800 w.

27275. Accounts of the Combined Turbine and Steam Plant of the Grosvenor-Dale Company. Ill. (E R-Dec. 1.) 1800 w.

*27283. Growth of the Steam Engine. Editorial (I. E-Dec.) 1400 w.

*27322. Steam Engine Pathology (E-Nov. 23.) 1200 w.

27402. Multiple Expansion Diagrams. Ill. Charles M. Jones (A M-Dec. 6.) 2800 w.

*27443. Steam Power Plants for Flour Mills. F. Riddell (Am M-Dec.) 1800 w.

Miscellany.

*26710. General Meeting of the Institution of Mechanical Engineers, with Abstracts of Papers (E-Nov. 2.) 6000 w.

*26739. Gas Engines of Large Power. Ill. (R W-Nov.) 450 w.

26802. Why Does a Bicycle Stand Up? Oberlin Smith (A M-Nov. 15.) 2300 w.

*26833. Cableways for Handling Heavy Loads. Ill. William Hewitt (S-Nov.) 2500 w.

*26887. An Approximate Method of Rectifying the Circumference of a Circle. F. P. Stevens (S J E-Nov.) 700 w.

26930. Pumping Coal (R R-Nov. 17.) 800 w.

27002. Where and Why Compressed Air is Cheaper than Steam. Frank Richards (A M-Nov. 22.) 3000 w.

*27041. The Modern Development of the Gas Engine. (Abstract.) James Atkinson (Eng L-Nov. 16.) 1400 w.

27070. Gas Fired Glass Furnaces. Ill. (A M & I W-Nov. 23.) 1500 w.

*27081. Labor Saving Machinery (I C B-Nov. 16.) 1200 w.

*27102. The Maxim-Nordenfelt Gun Works. Ill. (I & I-Nov. 16.) 11300 w.

27166. Why Does a Bicycle Stand Up? J. Begtrup (A M-Nov. 29.) 1000 w.

27194. The Restoration of the Purdue Laboratory (S E-Nov.) 1800 w.

We supply copies of these articles. See introductory.

†27217. Trial of a Vertical Triple Expansion Condensing Pumping-Engine, at the Trenton Waterworks. Samuel Webber and S. S. Webber (A S M E-Dec.) 900 w.

†27218. Tests on the Triple Engine at the Massachusetts Institute of Technology. C. H. Peabody and E. F. Miller (A S M E-Dec.) 1000 w.

†27219. Trial of a Leavitt Pumping Engine. F. W. Dean (A S M E-Dec.) 1000 w.

†27220. Trials of a Recent Compound Engine with a Cylinder Ratio of 7 to 1. F. W. Dean (A S M E-Dec.) 700 w.

†27221. Comparison of the Action of a Fixed Cut-off and Throttling Regulation, with that of the Automatic Variable Cut-off on Compound and Triple Expansion Engines. Charles T. Porter (A S M E-Dec.) 1600 w.

†27222. On the Theory of the Moment of Inertia. C. V. Kerr (A S M E-Dec.) 4000 w.

†27223. A Graphical Method of Designing Springs. G. R. Henderson (A S M E-Dec.) 1000 w.

†27224. The Application of Brakes to the Truck Wheels of a Locomotive. Gaetano Lanza (A S M E-Dec.) 600 w.

†27225. An Experimental Study of the Effect of the Counterbalance in Locomotive Drive Wheels upon the Pressure between Wheel and Rail. W. F. M. Goss (A S M E-Dec.) 3000 w.

†27226. Description of a Cam for Actuating the Valves of High-Speed Steam Engines. Charles T. Porter (A S M E-Dec.) 2700 w.

†27230. Stresses in the Rims and Rim-Joints of Pulleys and Fly-Wheels. Gaetano Lanza (A S M E-Dec.) 4000 w.

†27238. Results of Measurements to Test the Accuracy of Small Throttling Calorimeters. D. S. Jacobus (A S M E-Dec.) 1900 w.

†27241. The Law of Invention. Horace Pettit (J F I-Dec.) 8500 w.

27245. Are Our Patent Laws Iniquitous? A Rejoinder. R. D. O. Smith (E E-Dec.) 5800 w.

27248. Wooden Pulleys. Ill. R. D. O. Smith (E E-Dec.) 1500 w.

*27259. A Compensating Planimeter. Ill. (C. G. Nov. 23.) 700 w.

27263. The General Principles of Machine Design. C. H. Benjamin (M A-Dec.) 1000 w.

27324. The Proposed Locomotive Tests at Purdue (R R-Dec. 1.) 2600 w.

27325. The McLaren Dust Shield and Journal Box. Ill. (R R-Dec. 1.) 1200 w.

27327. Fire-Box Construction. Ill. (R R-Dec. 1.) 1400 w.

*27392. The Wind in Harness. Ill. J. H. Campbell (Mill-Nov.) 2400 w.

*27394. The Cyclone in Harness.—The Pneumatic Steel Warehouse Company Elevator. Ill. (Mill-Nov.) 3000 w.

27404. The Relative Efficiency of Different Abrasive Products in Common Use. Charles N. Jenks (Sc A S-Dec. 8.) 3200 w.

27416. The Moore Trench Machine on the Greene Avenue Sewer, Brooklyn, N. Y. Ill. (E N-Dec. 6.) 1600 w.

*27442. Government Protection of Inventions. C. R. Tompkins (Am M-Dec.) 1100 w.

27452. Hints Upon Smokestacks. J. H. Allen (Eng-Dec. 8.) 1000 w.

Serials.

13033. Practical Hints to Boilermakers and Templaters (M W-Began May 12—15 parts to date—30 cts. each).

18044. Motive Power and Gearing. Ill. E. Tremlett Carter (El-Began Dec. 1, 1893—26 parts to date—30 cts. each).

20182. The Elements of Boiler-Making. Ill. C. E. Fourness (L E-Began March—10 parts to date—30 cts. each).

24930. Some Notes for Enginemen and Firemen. W. H. Booth (E L-Began Aug. 31—8 parts to date—30 cts. each).

25384. Spacing Holes. Ill. Easy Way (A M-Began Oct. 4—4 parts to date—30 cts. each.)

25528. The Designing and Construction of Modern Steam Engines. Ill. Theodore F. Scheffler, Jr. (M A-Began Oct.—3 parts to date—15 cts. each).

25538. Testing of Engines and Boilers. Ill. Charles Day (P Eng-Began Sept. 21—6 parts to date—30 cts. each).

25922. Some Points in the Testing of Steam Engines (I & I-Began Oct. 5—5 parts to date—30 cts. each).

26181. Refrigerating Machines. Ill. A. R. Gale (M W-Began Oct. 19—Ended Nov. 16—5 parts—30 cts. each).

26463. The Slide Rule in the Shop. William Cox (M A-Began Nov.—2 parts to date—15 cts. each).

26488. American Steam Raising Plant (I & I-Began Oct. 26—Ended Nov. 9—2 parts—30 cts. each).

26590. Changing a Steam Plant to Improve Economy. Thos. Hawley (B J C-Began Nov. 10—Ended Nov. 17—2 parts—15 cts. each.)

26598. Fly-Wheel Accidents. J. J. Flather (E W-Began Nov. 10—Ended Nov. 17—2 parts—15 cts. each).

26661. The Selection of Motive Power. Charles E. Emery (E Mag-Began Jan—1 part to date—30 cts).

26752. The Cost of Steam Raising. J. Holliday (M W-Began Nov. 2—2 parts to date—30 cts. each).

26980. On Furnaces and Combustion (I & I-Began Nov. 9—1 part to date—30 cts).

27182. Notes on the Construction and Use of Pressure Gauges. C. R. L. Lemkes (M W-Began Nov. 23—1 part to date—30 cts).

27318. The Buckingham Works. Ill. (E-Began Nov. 23—1 part to date—30 cts).

27423. Repairing Steam Engines. Ill. T. W. Barber (S M-Began Dec. 1—1 part to date—15 cts).

MINING & METALLURGY

Chemistry of Iron.

FROM the chemical no less than the metallurgical point of view the condition and the effects of the various foreign elements present in iron and steel, either as impurities or purposely added, are always questions of the highest interest. Mr. John Parry has presented a notable paper on the subject before the South Wales Institute of Engineers, and his essay is reproduced in the *Iron and Steel Trades Journal*. It is impossible within the limits of a review notice to give an adequate idea of this paper in a popular form, and but a few of the points considered can be mentioned.

The author begins by saying that it is now generally admitted that when small quantities of foreign bodies, amounting in some instances to little more than traces, are added to iron its physical properties are thereby modified. "It would seem, however, that the part played by minute quantities of impurities in modifying the quality of iron is not easily explained by the ordinarily accepted theories of combination, solution or alloyage of one metal with another." The author points out that no reasonable formula can be assigned to a substance like ordinary steel, with 99 per cent. iron and the small and varying quantities of other elements, and yet that it is well known that minute quantitative differences in the relative amounts of these latter have a marked effect. Still, he believes, something akin to chemical combination must take place, since mere mixtures do not exhibit the phenomena of such combinations.

After remarking that it is not so long ago that the one-hundredth of a foreign element was disregarded by practical iron makers, the author proceeds to review some of the earlier hypotheses as to the constitution of iron and steel, which appeared to be endowed with peculiar physical properties not due solely to chemical variations. In consequence chemical analysis was considered as giving in most cases unreliable data, and that there were changes in physical properties to which analysis gave no clue. He considers it remarkable that the older metallurgists had really very nearly anticipated some of the theories recently advanced as to the allotropic state of iron. But the advent of the Bessemer process demolished earlier views by showing the necessity of ascertaining very accurately the chemical composition of the metal. Going to "what some are inclined to think" the opposite extreme, it was conceded that quality was practically a function of the composition of both iron and steel, while latterly there have been indications to modify this view. A plausible explanation of the discrepancies between chemical and mechanical tests may be found in the differences in temperature during manipulation. "At present there seems to be a common agreement that although the analysis alone is not reliable, and that the physical properties of steel are not always in accord with chemical analysis, yet the latter is an important factor which must not be ignored when endeavoring to forecast quality." In support of this the investigations of Webster are cited.

The relations of carbon to iron are peculiar, it conferring certain properties which do not pertain to other elements in steel; hence, as the author shows, while it is necessary in steels for certain uses where hardening, tempering and annealing are desirable (as in tool steel), in other steels (as for boiler and ship plates) it should be suppressed on account of unreliability. The three different states of carbon in iron and steel are described, and the author calls attention to the infusibility of carbon as placing it upon a different footing from the metals and metalloids, although later on he mentions the fact that the carbide of iron is the only compound yet isolated.

Mr. Parry goes rather deeply into the intricate subject of the relation of atomic weight to atomic volume, and the bearing

upon percentage weights in the total composition of steel; and here he follows in the lines laid down by Roberts-Austen, but thinks that the practical application of these facts is difficult and that we have not yet sufficient data. "Throughout it appears that heat plays an important part in modifying not only temporarily, but permanently, the physical properties of the metal . . . and the relative chemical mobility seems a function of the temperature applied."

Finally the author suggests for discussion the revival of an old theory—that "steel may be regarded as an intimate mixture of pure iron with other chemical compounds, such as sulphur and phosphorus compounds. . . These alloys must as a rule be of a lower fusion point than iron and may serve as a species of flux or cement, binding the iron together."

Future Coal Fields of Great Britain.

SOMETHING of a revolution in the geology of coal, as currently stated in the text books, has been started by Professor Lapworth, who in a recent lecture has advanced certain propositions which, although recognized by field geologists, either do not appear in the books of reference or are passed over with scant comment. In this and in some other respects the elementary text books are at a disadvantage because of limited space in which to discuss questions about which there is at least room for argument, and also because of the desire (and perhaps necessity) of putting things in a hard, dogmatic form that can be grasped by young students and thus avoid the danger of confusing their impressions. An abstract of Professor Lapworth's lecture is given in the *Colliery Guardian*, and indicates that it is a noteworthy contribution to the literature of economic geology. "About a generation ago," the speaker pointed out, "it was believed that coal was only formed at one special period of the earth's history [omitting the Tertiary examples, which were then not prominent] but the discoveries of the last twenty years have shown that coal could be formed at any period, and in any region, wherever there existed those moist, warm and partially flooded conditions demanded for its formation." This appears axiomatic; but the issue hinges upon whether these favorable conditions existed only at certain definite periods or at any and all. As it happened that in Europe, where geologic science had its origin and where observations were most numerous, the coal beds were almost wholly of Carboniferous age, that age was thus named as the coal-forming age *par excellence*. Later when the lignites and brown coals of the western United States became prominent, a solitary exception was noted. Professor Lapworth goes a step farther, and after citing a long list of coal fields not of Carboniferous age comes out with a clear and frank expression of the most advanced geologic opinion: "Indeed," he says, "it may be regarded as certain that coal is being formed in enormous quantities at the present day in many, if not all, of the great flood plains and deltas of tropical and sub-tropical rivers." Selecting the great flood plain and delta of the Mississippi as an illustration of one of these growing coal fields, he showed how the natural phenomena of such a district might afford the requisite conditions for the formation of coal, in part from plants growing in place, and in larger part from washed-in material.

The leading *motif* of the lecture was the outlook for the future of British coal resources—a most critical question, for the commercial and manufacturing supremacy of Great Britain is based upon its available stock of fuel. Professor Lapworth believes that all the well-known data, practical and theoretical, point to the conclusion that all the Midland coal fields are merely the visible fragments of a single delta-like sheet largely buried beneath an overlying and continuous sheet of red sandstone, and that the coals must extend practically unbroken beneath this red sheet from coal field to coal field, within, however, certain original geographical limits beyond which coal would not be looked for, and he cites several observations in support of this view. "Every area in which coal might be expected must be carefully studied by itself individually, and only those spots selected for trial shafts which have the greatest

number . . . of probabilities in their favor." To this might be added that, as the probable depths are so extreme, the diamond drill is the most economical means of exploration. Should Professor Lapworth's hypothesis of parallel conditions between British coal fields and others of later date and still forming hold good, a few test cores from any depth not mechanically prohibitive for mining—say down to 6000 feet or so—ought to show whether the coal, if it exists and is of workable thickness, can be profitably mined.

Chemistry in the Foundry.

SOMEWHAT similar to the early development of chemistry in blast-furnace work has been its recent history in the foundry—a gradual and at first slow departure from empirical methods, in which chemistry played little or no part, to a more systematic and scientific procedure. The *Engineering and Mining Journal* traces this analogy in evolution along similar lines; notes that early trial in the foundry, as in the smelting furnace, sometimes resulted in failure; alludes to the experiments of pioneer chemists, and takes pleasure in observing that progress is now rapid, although much remains to be learned in this direction. "One trouble," says the *Journal*, "has been that founders and others will not recognize that a knowledge of the chemical or physical features of either pig iron or castings is not sufficient," and points out that many small details of operating have much to do with the results, "Neither the chemist alone nor the founder can bring about the best work; it requires both in one, the chemical knowledge combined with the practical ability; and the latter is the result only of experience."

The Coolgardie Gold Fields.

AN interesting letter about this new gold district of Western Australia is copied by the *Australian Mining Standard* from the Bendigo *Advertiser*. The writer was there in the early period of the excitement and depicts the features common to all great mining rushes, to which are superadded some incidents peculiar to the arid region in which the new discoveries lie. His view is realistic and entirely conservative. "The exaggerated information about Coolgardie and the new finds, as filtered through the press, causes one to wonder when the boom will end and what will be the result. . . . Coolgardie and the surrounding gold fields are undoubtedly one of the best avenues for young men in Australia for advancement in life. They will have to take their chance; . . . but it is a strange fact that not more than one-third of the number that have arrived have remained. . . . New rushes are of almost weekly occurrence, but the great majority of them prove complete duffers."

A graphic pen picture is presented of a rush to one of the new finds, the "Wealth of Nations." It is hardly fair to condense this lively account into a few words, but the salient points may give some idea of how a rush is started and how it results: On the afternoon of mail day, when the crowd were waiting for letters at the post office at the main camp, a camel train was noticed coming in at a brisk walk until it stopped at the bank. Throngs gathered around to see what the loads were. The camels were unloaded, and it could be seen from the heavy pack bags that a large find had been made.—People flocked from all sides eagerly discussing the find and its probable locality. The discoverer was besieged by anxious questioners, but remained mute. After a while, an impromptu show was given in one of the rooms of the bank, to which the public were admitted in parties of six. A table was set out with some of the nuggets and rich rock. One piece, "Honest John," of 150 pounds "with gold standing out like peanuts from the quartz," was the chief attraction. Instantly the excitement increased and hurried preparations were made to set out in search of the "find," and parties of prospectors were out almost at once; but it was not until two days later that the way was made known. The course lay through an arid region where the only water to be had was at far separated "soaks" where the government had placed catchment tanks; so water was the principal freight carried. When the correspondent reached the place, water was

selling at $1.25 a gallon. A patrol of troopers were out to keep order, but there were attempts at claim jumping. Small "alluvial" claims were rapidly staked off around the discovery point, and active digging began. As is usual, a very few men, a dozen or so, were successful, but the great majority found little or nothing. The gold hunters kept thronging in and going away disappointed, and the hardships were severe. "Nobody is considered anybody here," says the writer, "who has not done a 'perish,' that is, been without water five or six days." Evidently prospecting around Coolgardie is not exactly a "picnic," in either the literal or the slang sense of the word. From the time the letter was written until this notice of it appears some three months have elapsed, during which the cables have brought much later news, showing that things have settled down to more systematic shape, and while work is now on a more extensive scale the first wild enthusiasm has considerably toned down.

Electro-Deposition of Gold.

THE already extensive literature of the cyanide process has a recent addition in a paper contributed by Mr. E. Andreoli to *Elektrische Zeitung* and translated by the *Electrical Review*. The author begins by saying that to dissolve gold from its ores by means of a cyanide solution is one thing; to catch the dissolved gold is another thing, rather difficult, as gold cannot be precipitated from a cyanide solution by iron sulphate or sulphuretted hydrogen, as from a chloride solution. He considers the usual method of precipitation in zinc shavings as a crude one, which "ought soon to be replaced by a more rational and practical method of electrolytical deposition," and then refers to the Siemens electrolytic precipitation process, in which lead is used as a cathode. He considers the weak point in all such systems (including the mercury one) to be the important question of anodes, which does not seem to him to have been very successfully settled. He ridicules the idea of using zinc as an anode, mentions the use of carbon, and says that the question of iron anodes has not been well understood, studied or worked. The electrolysis of a very weak solution of potassium cyanide and gold comes to almost the same thing, he believes, as the electrolysis of plain water. Mr. Andreoli, commenting on a statement by another writer in regard to strength of solution, remarks that "electroplaters will be much surprised to learn that a weak solution is as good as a strong one." The Siemens solution is extremely weak and the intensity of current very low. The article contains sharp criticisms of other statements that have been advanced as to this process and is especially combative of a paper lately read by Mr. A. von Gernet before the Metallurgical Society of South Africa.

Coal Interests of Southwest Virginia, etc.

A CORRESPONDENT of the *American Manufacturer* who has just made an extensive tour of observation through the coal fields of southwestern Virginia, West Virginia, Kentucky and Ohio, makes an interesting report as to the probable future magnitude of the coal and coke production of that region and especially of the two Virginias, when the owners of the beds shall have constructed a few more lateral, tributary, branch railroads to tap the whole area. Already the coal and coke travel of the two main lines runs up into the millions of tons annually, although the industry is still in its infancy. These roads traverse what the writer believes will in a few years be conceded to be the greatest and richest field, in quantity and quality combined of the coals, in all the world. Up to 1880 the very existence of the important deposits of southwestern Virginia was not only unknown but denied on professional authority. At present numerous mines are in active operation and many are remote from each other, indicating values in the intervening areas yet unopened. In a little more than a dozen years scores of millions of dollars have been there invested in the building of railroads, towns and furnaces, the opening of mines, the construction of coke ovens near them and of wharves at seacoast terminals. The writer deals in strong statements, but

disclaims any overestimate or exaggeration. The Imboden bed is described as 8 feet thick without a parting, and known to extend over an area of 50 or 60 square miles. Here a bench of 50 ovens is to be soon in operation as a beginning, to supply iron furnaces so situated that the ores, coking coals and limestone are in the immediate vicinity of each other. This (the Big Stone Gap) district is an example of others cited that are in the neighborhood. Near Colburn is the property of one coal and iron company having 55,000 acres of coal land in Virginia and 45,000 in Kentucky, and the product from only eight of its mines yet opened is 50,000 tons a month. Another company is building 400 coke ovens there. About 100 miles distant (with little mining being done now in the intervening space on account of the financial depression) is the Flat Top or Pocahontas field, so well known for its high-grade steam and coking coals and for its already great output. The correspondent could find no one to tell him just how many ovens were in operation, but saw "hundreds upon hundreds in full blast," and says that for miles the lateral ravines and gorges have been seized upon by coke burners. He gives a vivid description of what he saw: 'Looking down upon such a scene as is here presented for miles, into the red-hot ovens, licking out their fiery tongues of flame, from amid the smoke and soot-blackened men moving hither and thither, one has a vivid realization of some of the scenes in Dante's 'Inferno.'" His language is not all so picturesque, as he gives many details of more practical import; but asserts that "centuries hence will hardly witness the exhaustion" of the Pocahontas beds, with their great area and thickness.

New Applications of Iron and Steel for Structural and Mining Purposes

AT the last conference of the British Iron Trade Association Mr. Jeremiah Head read a paper on the above subject. It is quoted in the *Iron and Coal Trade Review*. The author questioned whether as much had been done as might be in Great Britain to stimulate the demand for iron and steel in directions other than railways, shipbuilding and tin plates, which are three of the chief channels of consumption, and showed that in the United States and on the continent of Europe a great deal more had been attempted and achieved in the way of applying iron and steel to other and more general uses, more especially in substitution for timber, bricks and stone. The paper first deals with the use of iron and steel for public and private structures, in which wrought and cast iron have been used for beams and columns and now steel is used not only in floor beams and columns, but also in the frames of windows, roof work, supports for roofs, and even in the foundations in connection with concrete—in fact in everything that assists in carrying weight, so that many buildings are practically all-steel structures. The full extent of this movement is difficult to estimate, but Mr. Head mentions the large number of American iron and steel companies that are giving more attention to structural steel than to any other branch. More than 20 per cent. of the total production of steel ingots in the United States is now absorbed in the structural specialties.

Another great prospective use for steel is in the construction of railway cars, in which timber is expected to be supplanted by steel not only for the under frames but for the entire framework. Mr. Head estimates that there are now at least 2½ million vehicles of all kinds on the railroads of the world, not counting locomotives. The maintenance and increase of this stock represents, he thinks, a certain positive demand upon which the steel industries may safely reckon. The suggestion of Mr. A. E. Hunt to use an iron-aluminum alloy for this purpose is referred to, with the remark that the difference in price will for some time to come prevent that alloy from being placed in favorable competition with steel.

The use of iron or steel for shaft frames and props in French coal mines is said to be becoming very general. "Here again," says Mr. Head, "is an application from the adoption of which in Great Britain and some of its dependencies a new demand

may be expected. The extent to which timber is used in mining is enormous, and if only it could be shown to be of advantage to substitute steel its use would rapidly extend. The cost of steel is lower in England than in France, so that if it pays to adopt it in the latter country it would be still more likely to pay in the former." [Here is food for thought for managers of mines in some parts of the United States, where timber is dear and steel, relatively speaking, cheap.]

Besides the cases mentioned at some length, the author remarks that there are many others in which the use of steel might be introduced or extended with advantage, as for ornamental purposes, for balconies, doors, windows, conservatories, fencing and a multitude of other uses. He calls attention to the pains and expense incurred by the German Iron Trade Association in publishing a work designed to bring under the eye of all who are concerned in building operations the advantages to be gained by the substitution of steel, which is thought to have already had the effect of directing more attention to the subject and of enlarging the area of steel consumption for constructive uses.

Losses in the Fire Assay.

In a paper read at the October meeting of the American Institute of Mining Engineers Mr. H. V. F. Furman discusses the question of losses in the fire assay for gold and silver. The purpose of the paper is to call attention to the desirability of more uniform methods of assay. The sources of error, the author points out are improper sampling, losses of the precious metals during fusion, scorification and cupellation, imperfect elimination of the base metals in the cupel, and imperfect extraction of the silver in the parting by nitric acid. Of these losses that during fusion is the greatest source of error. In cupellation the temperature is a more important factor than the quantity of lead or of base metals other than lead. The difficulty of removing the last traces of silver from the gold is recognized, and the author suggests certain precautions in parting. A table is given showing the results of experiments to determine the losses in the crucible assay of ore.

INDEX TO LEADING ARTICLES.

The journals quoted are indicated by initials, and their full titles are given in the opening pages of the Review. Other abbreviations are, Ill=Illustrated; W=Words.

Metallurgy.

*26498. Chemistry of Iron: Modern Practice. John Parry (I & S-Oct. 27.) 3300 w.

26521. Losses of Gold and Silver in the Fire Assay Howard V. Furman (E M J-Nov. 3.) 700 w.

*26682. Presidential Address of William Jacks to the British Iron Trade Association (I C T-Nov. 2.) 3600 w.

*26683. New Applications of Iron and Steel for Structural and Mining Purposes. Jeremiah Head (I C T-Nov. 2.) 2200 w.

*26684. Special Conditions Affecting England's Iron Trade with India. Jeremiah Lyon (I C T-Nov. 2.) 3700 w.

*26685. The Scotch Pig-Iron Trade. A. B. Low (I C T-Nov. 2.) 2500 w.

*26704. The Atlas Works, Sheffield. Ill. (Eng L-Nov. 2.) 2000 w.

*26719. The Cost of Gold Milling. Editorial (M J-Nov. 3.) 1800 w.

26862. Melting Tin Plate Scrap in a Cupola. Edward Kirk (Met W-Nov. 17.) 1600 w.

*26965. Effects of Metals and Metalloids on Iron and Steel. Harry Silvester (P Eng-Nov. 9.) 2000 w.

*26975. Changes in Iron and Carbon During Tempering. George Charpy (C G-Nov. 9.) 600 w.

*26979. Electro-Deposition of Gold. E. Andreoli (E R L-Nov. 9.) 1800 w.

27011. Preliminary Tests on the Strength of Copper. A. Martens (Ir Age-Nov. 22.) 2000 w.

27012. Malleable Castings from Coke Iron. Editorial (Ir Age-Nov. 22.) 900 w.

27021. The Present Status of Face-Hardened Armor (Abstract) W. T. Sampson (E N-Nov. 22.) 1800 w.

*27043. The Cyanide Case. Editorial (Eng L-Nov. 16.) 1200 w.

*27051. Wet Iron Ores and Their Metallic Values. Walter J. May (C G-Nov. 16.) 800 w.

27059. The Crystallization of Iron. H. M. Howe (E M J-Nov. 24.) 2500 w.

27063. The Wentworth Goldfields Proprietary Company's Stamp Mill at Lucknow, New South Wales, Australia. F. M. Drake (E M J-Nov. 24.) 800 w.

*27082. Tempering Tool Steel. F. M. S. (I C B-Nov. 16.) 1000 w.

We supply copies of these articles. See introductory

*27104. The Condition of the Iron Trade of Great Britain (I C T–Nov. 16.) 1800 w.

*27105. Different Types of Basic Open-Hearth Steel Furnaces. Bernard Dawson (I C T–Nov. 16.) 3800 w.

*27106. An Important Field for Blast Furnace Economy. Editorial (I C T–Nov. 16.) 800 w.

*27127. Cyanide and Electrolytic Cyanide Solutions. Emile Andreoli (E R L–Nov. 16.) 2500 w.

27138. The Antiquity of Iron and Steel. G. D. Hiscox (Sc A–Dec. 1.) 1500 w.

†27151. The Electro-Metallurgy of Gold and Silver. A. L. Eltonhead (P E C P–Nov.) 2700 w.

27186. Comparison of Strength in Specialty Mixing of Cast Iron. Gus C. Henning (Ir Age–Nov. 29.) 1500 w.

27188. How Shall We Gauge Wire and Sheets? Oberlin Smith (Ir Age–Nov. 29.) 4800 w.

27205. Determination and Detection of Copper. M. Haupt (E M J–Dec. 1.) 1300 w.

27212. Report of Committee on Comparison of Round and Square Test-Bars, with Discussion (I T R–Nov. 29.) 4800 w.

†27229. Notes on Steel Forgings. G. M. Sinclair (A S M E–Dec.) 2800 w.

†27231. Report of Committee on Uniform Methods of Testing Materials. Monograph of W. J. Keep, Covering Relative Tests of Cast Iron, with Chemical Determinations of the Fourteen Series, by R. N. Dickman (A S M E–Dec.) 4500 w.

†27236. Rustless Coatings for Iron and Steel Galvanizing, Electro-Chemical Painting, and Other Preservative Methods (2d Paper). Ill. M. P. Wood (A S M E–Dec.) 21000 w.

27308. The Blast Furnace. E. C. Potter (C M R–Nov.) 2400 w.

†27315. Some Recent Contributions to Our Knowledge of Metallic Reducing Agents. H. F. Keller (J A C S–Dec.) 3900 w.

*27320. The Stora Kopparbergs Bergslags Aktiebolag. Ill. (E–Nov. 23.) 2000 w.

*27323. The Early History of Crucible Steel. R. A. Hadfield (E–Nov. 23.) 5000 w.

27395. Malleable Castings from Coke Pig Iron. Ill. (Ir Age–Dec. 6.) 600 w.

27448. Dressing Spathic Iron Ore at Allevard (E M J–Dec. 8.) 1000 w.

Mining.

26523. Gold Mining in Ecuador. A. F. Saabye (E M J–Nov. 3.) 1300 w.

26679. Coal Interests of South Western Virginia. J. D. Imboden (A M & I W–Nov. 9.) 3000 w.

*26697. Coal Mining in the Transvaal (C G–Nov. 2.) 1000 w.

*26698. Newfoundland: Its Geology, Useful Minerals and Mining Legislation. M. de Launay (C G–Nov. 2) 1400 w.

*26699. The Coal Trade of the East (C G–Nov. 2.) 1100 w.

*26718. West Australian Gold Fields.—Interview with W. H. Webb (M J–Nov. 3.) 2400 w.

*26732. Explosives for Mining Purposes. Editorial (P Eng–Nov. 2.) 900 w.

*26773. An Expert's Opinion on West Australian Mines (Min W–Nov. 3.) 1700 w.

*26834. Stones of Sweden. (Extract.) Hjalmar Lundbohm (S–Nov.) 1800 w.

26868. Waste of Coal in Mining. Selwyn M. Taylor (E N–Nov. 15.) 2000 w.

26911. The Harney Peak Tin Mines. Ill. Arthur J. Morse (E M J–Nov. 17.) 700 w.

*26925. Future Prospect of the Thames (N. Z). J. Park (A M S–Oct 6.) 1300 w.

*26926. The Mitchell's Creek Freehold Gold Estate, Wellington (N. S. W). Ill. (A M S–Oct. 6.) 1000 w.

*26927. The Coolgardie Goldfield (W. A.) An Interesting Letter (A M S–Oct. 6) 2000 w.

*26928. The Croydon Goldfield (Q.) (A M S–Oct. 6.) 1500 w.

26938. Cost and Efficiency of Underground Pumping Engine (S V–Nov. 15.) 1200 w.

*26940. Consolidated Gold Fields of South Africa.—The Director's Report (M J–Nov. 10.) 1500 w.

*26941. The Boom in Gold Mining. Editorial (M J–Nov. 10.) 700 w.

*26959. Coal Mining and the Health of Miners (I C T–Nov. 9.) 2000 w.

*26972. An Interesting Coal Pit (C G–Nov. 9.) 900 w.

*26973. Our Future Coalfields (C G–Nov. 9) 1000 w.

*26974. The Aerial Rope System of Transport in Victoria (C G–Nov. 9.) 1400 w.

*26976. Mines and Minerals in Scotland—Review of Book by D. Ross Stewart (C G–Nov. 9.) 3000 w.

†26991. Our Indian Mining Letter. Lepidodendron (I E–Oct. 20.) 1100 w.

*26993. A Juggle.—Plain Words about the Consolidated Goldfields of South Africa (Min W–Nov. 10.) 1400 w.

*26994. A Remarkable Gold Mine—Londonderry (Coolgardie) (Min W–Nov. 10.) 1000 w.

*27000. Western Australian Goldfields. Editorial (E–Nov. 9.) 1800 w.

*27048. Cretaceous Coal in North America. (C G–Nov. 16.) 900 w.

*27052. Disposal of Waste at the Pit-Head. Ill. (C G–Nov. 16.) 2000 w.

27061. The Coal Industry in Belgium During 1893. Emile Harze (E M J–Nov. 24.) 1100 w.

*27094. Chili as a Coal Producing Country (B T J–Nov.) 750 w.

*27107. Explosives for Mining Purposes (I C T–Nov. 16.) 2000 w.

*27112. Quarrying. C. Le Neve Foster (M J–Nov. 17.) 1800 w.

*27113. The Gold Output of the Witwatersrand (M J–Nov. 17.) 1000 w.

27155. Proceedings of the Annual Meeting of the California Miners' Association.—The Speeches, the Resolutions and the Suggested Changes in the United States Mining Laws (M S P-Nov. 24.) 12000 w.

27156. Mineral or Agricultural Character of Land.—Argument Submitted to the Congressional Committee on Mines and Mining (M S P-Nov. 24.) 6500 w.

27157. Department Rulings and the Miners. A. H. Ricketts (M S P-Nov. 24.) 3000 w.

27172. The Drainage Works of the Ontario Silver Mine, Utah. Ill. W. P. Hardesty (E N-Nov. 29.) 4500 w.

27203. The New Pedrara Onyx (E M J-Dec. 1.) 1000 w.

27204. Tin Mining in Perak (E M J-Dec. 1.) 1200 w.

27213. Mining Industries of Australasia Min R-Nov. 15.) 2000 w.

27306. Mining in British Columbia. H. J. E. (C M R-Nov.) 2400 w.

27307. Mine Explosions Generated by Grahamite Dust. Ill. William Glenn (C M R-Nov.) 5000 w.

27361. Minerals of Appalachian System. William Brewer (T-Dec. 1.) 1400 w.

27430. Continued Proceedings of the Annual Meeting of the California Miners' Association (M S P-Dec. 1.) 15500 w.

27431. Investments in Mines. C. W. Cross (M S P-Dec. 1.) 3300 w.

27432. The Successful Application of Electricity to the Operation of Mines. W. F. C. Hasson (M S P-Dec. 1.) 2500 w.

27433. The Hydraulic Gravel Elevator System in Hydraulic Mining. R. H. Campbell (M S P-Dec. 1.) 1400 w.

27446. Gold Deposits of Colombia and Ecuador. T. Waln-Morgan Draper (E M J-Dec. 8.) 1800 w.

Miscellany.

*26660. Laboratory Training for Mining Engineers.—The Course at the Massachusetts Institute of Technology. Ill. Robert H. Richards (E Mag-Jan.) 2000 w.

26815. In the Borax Marshes (M S P-Nov. 10.) 600 w.

*26951. Mineral, Metallurgical and Coal Industries of Sweden in 1893 (Eng L-Nov. 9.) 1500 w.

27004. A History of the Miners' Movement (M S P-Nov. 17.) 2300 w.

*27093. Development of the Russian Mining and Metallurgical Industries (B T J-Nov.) 1100 w.

*27393. November Excursion of the Western Society of Engineers.—Visit to the Illinois Steel Works (Mill-Nov.) 1800 w.

Serials.

19682. The Sinking and Equipment of Shafts. Ill. (E-Began Feb. 2—7 parts to date—30 cts. each).

21814. Plate Moulding. Ill. J. Horner (P Eng-Began April 27—10 parts to date—30 cts. each).

24075. Manufacture of Tin Plates (I & I-Began July 27—5 parts to date—30 cts. each).

26031. European Phosphates. C. C. Hoyer Millar (M R-Began Oct. 19—5 parts to date—15 cts. each).

26118. Iron Ores. John Randall (C G-Began Oct. 12—4 parts to date—30 cts. each).

26139. Aluminum. A. Humboldt Sexton (P Eng-Began Oct. 12—2 parts to date—30 cts. each).

26293. The Zinc Mining Industry of Southwest Missouri and Southeast Kansas. J. R. Holibaugh (E M J-Began Oct. 27—Ended Dec. 8—7 parts—15 cts. each).

26386. Proper Foundry Construction, and the Apparatus to be Used. Simpson Ballard (T-Began Nov. 1—3 parts to date—15 cts. each).

26556. The Phosphates of the World. Francis Wyatt (J F I-Began Nov.—2 parts to date—45 cts. each).

26561. The Cornwall Ore Hills. John Birkinbine (Ir Age-Began Nov. 8—3 parts to date—15 cts. each).

26687. The Coalfields of Labuan, Borneo. Robert Fisher (I C T-Began Nov. 2—Ended Nov. 9—2 parts—30 cts. each).

26690. On Nickel Steel. (I & I-Began Nov. 2—Ended Nov. 23—2 parts—30 cts. each).

26693. The Effect of Stress on the Corrosion of Metals. Thomas Andrews (I & I-Began Nov. 2—2 parts to date—30 cts. each).

26816. Notes on the Gold-bearing Black Sands of California. J. A. Edman (M S P-Began Nov. 10—1 part to date—15 cts).

26826. Open Hearth Steel. Ill. (Ir Age-Began Nov. 15—2 parts to date—15 cts. each).

26912. Historical Sketch of Lead and Zinc. Arthur Winslow (E M J-Began Nov. 17—Ended Nov. 24—2 parts—15 cts. each).

27049. Mining Plant at the Freiberg Exhibition. O. Lange (C G-Began Nov. 16—2 parts to date—30 cts. each).

27111. The Profits of Gold Mining. Nicol Brown (M J-Began Nov. 17—2 parts to date—30 cts. each).

27319. The Mineral Resources of the United States. (E-Began Nov. 23—1 part to date—30 cts).

27329. Coal Mining Economy up to Date (I C T-Began Nov. 23—1 part to date—30 cts).

27356. Further Experiments in Amorphous Gold. Henry Louis (M J-Began Nov. 24—1 part to date—30 cts).

27357. The Practical Operation of the Cyanide Process on the Rand. M. Eissler (M J-Began Nov. 24—1 part to date—30 cts).

27358. Motive Power for Mining Machinery (M J-Began Nov. 24—1 part to date—30 cts).

27450. Cupola Tuyeres. Ill. Edward Kirk (Met W-Began Dec. 8—1 part to date—15 cts).

MUNICIPAL ENGINEERING

Utilization and Purification of Sewage.

IN this department of our December number, was described a system of irrigation by sewage carried out at the city of Trinidad; and while it was stated that this was a new departure in the United States, reference was also made to the fact that the system had made considerable progress in European countries. A very comprehensive editorial in *The Engineer* (Nov. 9) not only indicates that this system has progressed to what may be properly called a somewhat extended use, but also lays down the principles which must be observed in carrying out the method in order that it may be successful in fertilization of the soil, and at the same time be regarded as safe from a sanitary point of view.

First, as to the time the system of fertilization by sewage has been in use, it may be said that it is of ancient origin, being "the oldest method adopted for dealing with a national and social problem, which, in point of magnitude, gravity, and urgency, has now assumed proportions that have rarely been equalled and probably never surpassed." More than three hundred years ago Bunzlau, in Prussia, disposed of its sewage in this way. Edinburgh, in Scotland, utilized its sewage nearly two centuries ago; and Milan in Italy, ranks nearly with Edinburgh in the early adoption of this method. In Asia, the use of sewage for fertilizing land was practiced earlier than in Europe.

Purification of sewage and its utilization are distinct methods, though both may be employed together. As to the question "whether the agricultural utilization of sewage should include a preliminary process of purification or clarification before it is passed on to the land (not necessarily by chemicals) is a subject concerning which engineers and scientists are not altogether agreed." When applied in the raw state it may be attended with danger to public health by saturating the soil with septic elements, and this is a question to be carefully pondered before adoption of sewage irrigation for any town, no matter how urgent the case may be. Whether this is likely to occur or not, depends somewhat upon the soil upon which the sewage is distributed; "but a great deal more upon the character and quality of the sewage itself." It is certain, also, that the manner of application of sewage to land has an important bearing upon the question of danger. A certain quantity varying with the nature of the land, can be absorbed. Any surplus over this remains to contaminate the immediate locality it may be to a dangerous extent. At Edinburgh, where raw sewage has for a very long time been applied to soil, evil results have not followed.

"It should not, however, be forgotten that this statement should be qualified by another, which is to the effect that the Craigentenny meadows are never allowed to be saturated persistently with sewage. When a sufficient quantity has been run on to them, the surplus is carried away to the sea. At Berlin, which, with its acquired land of 19,000 acres for sewage farms, is supposed to set an example to the rest of the world, both the broad irrigation and filtration principles are put into practice. A difference worth notice is made in the treatment of the plots upon which crops are grown and those used for the cultivation of grass. In irrigating the former, the sludge is allowed to pass on to the land with the sewage, and consequently remains there after irrigation, when it is ploughed deeply into the ground. In the case of the sewaging of the grass plots there are catch pits provided which intercept the sludge, as it was found that it clogged the surface and seriously interfered with the growth of the grass. When raw sewage is turned on to land the latter acts, no doubt, in the first place as a simple mechanical filter, leaving the heavier and coarser particles on the surface. The liquid

portion which contains the dissolved ingredients and the lighter and smaller particles in suspension, penetrates into the soil, and thus accomplishes the double purification already referred to."

The sewage farms of Gennevilliers, near Paris, are said not to be regarded with the same admiration by French sanitary engineers as would be inferred from their frequent citation in argument by advocates of sewage utilization. French farmers however, who are thus enabled to raise profuse crops without paying for fertilizing material, are loud in its praise. The quality of Paris sewage, is however, very much better adapted to sewage farming than that of many other towns, in which discharges of various materials into sewers as wastes from manufacturing establishments are abundant. As illustrating the principle that quality has much to do with the practicability of this method of sewage disposal, the history of sewage works at Wolverhampton, England, is instructive.

" The sewage farm there was purchased some twenty-five years ago, and occupied a site possessing the advantages of receiving nearly all the sewage of the borough by simple gravitation. For some years the local authorities made most laudable attempts to effect agricultural utilization by means of the broad irrigation principle and that of intermittent downward filtration. Their efforts were unfortunately all in vain, and they were ultimately driven to the conclusion that precipitation, or a preliminary treatment of the raw material, in some form or another, must be undertaken before it could, with any beneficial results, be turned on the land. The fact was that the sewage was rendered so foul by the quantity of refuse, waste water, and by-products of the numerous trades and manufactures in the town and district that it was utterly unfit to be applied directly in its crude state to the soil. It was found that when the sewage of only fifty persons on one acre was the proportion employed, the purification effected was of most perfunctory character, notwithstanding that the percolation extended to a maximum depth of 6 feet. By excluding as much as possible the storm waters from the sewers, by the construction of precipitation works, by the erection of a plant for pressing and consolidating the sludge, and by the proper preparation of the quantity of land for the final treatment of the effluent, the Sewerage Committee has successfully overcome the difficulties formerly besetting it."

But a still worse set of conditions was encountered at Nuneaton, England. Here materials discharged into the sewage are positively destructive to vegetable life. Utilization for fertilizing is not attempted, but simply clarification to an extent that will permit the liquid to be discharged into the nearest stream. Precipitation by the lime and alumina process, followed by filtration through sand and polarite, are the means by which clarification is effected. The chemical treatment has sometimes to be repeated before the material is brought to a proper state for filtration.

The fact that chemical treatment does not always purify, but only clarifies sewage ought not to be overlooked. Mere clearness of the liquid is not complete evidence of its purification. As to the assertion that if in this state " it be discharged into a river, it will, after a brief period revert to the same condition of impurity and pollution as it possessed previously to precipitation," it is replied that " experiments conducted at Salford with polarite, and also with an electrolytic process, tend to rebut this theory." The electrolytic process promises well, but its cost is rather high.

Estimates of the extent of land needed for the complete utilization of the sewage of Paris and London have been made. For Paris the estimate made of 150,000 acres is thought in England to be largely excessive; and, based upon results at Berlin, an estimate of 60,000 acres is judged enough to utilize the entire sewage of London.

Color of Water.

THE objectionable appearance of potable water supplied to many cities is a matter of notoriety. This arises principally from the presence of vegetable matter, and in a paper on the subject by Desmond Fitz-

gerald and William E. Foss, in the *Journal of the Franklin Institute* for December, this subject is considered with reference to scales for measuring the amount of the discoloration. An example of such discoloration is met with in water taken from the Sudbury river which is one of the principal sources of supply for the city of Boston.

"The area of the water-shed above the point of taking, is about seventy-four square miles. On this area several large storage reservoirs have been built for the purpose of equalizing the yield of the streams. As the sites of the reservoirs have been mostly stripped of all organic matter the effect of storage is to reduce the color of the water delivered by the feeders, but as it is impracticable to keep the water stored long enough to decolorize it completely, much study has been given to the source and amount of the color delivered by the streams supplying the reservoirs, and it has been found, as was expected, that the swamps and meadows were the principal sources of color. In July, the color of the water coming from the swamps is a rich reddish-brown, and in autumn, after the leaves have fallen, the color has more of a greenish cast. The color of the brooks varies constantly during the year, depending largely upon conditions which cannot be now discussed. In winter the color is naturally low, in the spring the color is high, reaching its maximum in June, and a second maximum occurs in December.

"In making plans for the improvement and drainage of the swamps it became important to be sure of the measurement of the colors, and as the color of the Boston water is almost an exact gage of the organic matter which it contains, it also became important that the color of the water delivered to the consumers should be readily and accurately measured on some correct scale."

The method of transmitted light with what are known as nesslerized ammonia standards has been found for various reasons not to be satisfactory, and an attempt to replace them by natural water standards has proved the latter to be also open to objection. They do not change their color so rapidly as the nesslerized ammonia solutions do, but it is difficult to standardize them by the nesslerized solutions because of the difficulty of insuring similarity of conditions in preparing the solutions. Other difficulties were also encountered which, added to the one already noted, renders it desirable to seek a different standard. This has been found in the platinum standard recently suggested by Dr. Allen Hagan, originally described in the *American Chemical Journal*, Vol. XIV, No. 4. For the method of preparing this standard and its use, the reader must consult the paper itself, which contains also a great deal of useful information relative to this kind of work which will be highly serviceable to engineers in charge of water works, and is also of general scientific interest.

Improved Methods in Laying Asphalt Pavements.

FROM the annual report of Capt. Chas. T. Powell, Engineer Commissioner of the District of Columbia (300 pages) an extract on the subject named is printed in *Paving and Municipal Engineering*. This is of general import, and it contains information relating to a class of street improvements now in active progress in most of our large cities.

The proportion of stone dust in asphalt mixtures for paving should be considered with reference to the quality of the sand as relates to the size grains. The function of this dust is regarded by Mr. Powell as being to "stiffen the cement" in voids between granules. With the rather coarse sands of the Potomac river he has found it well to use 15 per cent. of stone dust, thus obtaining a "tougher and more desirable surface." To shorten the time heretofore needed in refining asphalt the following method has been adopted: "The departure has consisted in the use of high-pressure steam in large gangs of pipe as a source of heat and a jet of air or of live steam as a means of agitation of the mass of pitch, thus preventing the formation of a core and the overheating of that portion of the pitch adjacent to the shell of the still. A

considerable saving of time and material has been accomplished in this way, but it is still an open question as to how the quality of the product will compare with the old process material. In this connection the form of test for refined asphalt of allowing a certain sized lump of the material to flow down an inclined glass at temperatures above its flowing point, side by side with certain standard pieces, which Prof. Bowen has developed, has proved of value, as it shows the relative softness of materials and smoothness or lack of impurities."

It is added that "the oiled asphalt has shown an improvement, being more uniform in consistency. The use of a new hot roller in front of the regular roller, which has been introduced as a substitute for the ordinary oiler hand roller, is stated to have proved a distinct advance over the old method, in going over the freshly-raked surface mixture for the first time. It keeps all oil from reaching the surface, as occurred with the hand roller, and obviates the necessity of having men walk upon the surface before it has been compacted, thus giving a much more uniform consistency to the whole mass."

As a partial or complete substitute for the broken stone, in the present hydraulic base of broken stone, sand and natural hydraulic cement, Capt. Powell thinks it would be desirable to try a "good river gravel," and he asserts that "concrete made of gravel rams much better than that made from broken stone, and can in consequence be made much drier, and is proportionately stronger."

"In the same way as in hydraulic concrete, I would recommend that experiments be made; directed toward determining the possibility of substituting gravel for broken stone in binder. The objection, which has been raised, that such a binder would roll, I do not think can be sustained."

INDEX TO LEADING ARTICLES.

The journals quoted are indicated by initials, and their full titles are given in the opening pages of the Review. Other abbreviations are, Ill=Illustrated W=Words.

Gas Supply.

*26667. Gas Purification and Sulphate Producing. W. Belton (C I J-Nov. 3.) 1100 w.

*26694. Combustion Products of Welsbach Burners; Reports of Professor Renk, Dr. Bunte and Dr. Kruger (G W-Nov. 3.) 4500 w.

*26695. Notes on Herr Niemann's Paper on the Strains in Gasholder Guide-Framing. F. S. Cripps (J G L-Oct. 30.) 1500 w.

*26696. Unaccounted-for Gas. Lewis T. Wright (J G L-Oct. 30.) 1600 w.

26759. One of the First Meter Makers in the United States. H. C. Slaney (A G L J-Nov. 12.) 3000 w.

26760. Applications of Chemical Technology to Gas Manufacture. George H. Harper (A G L J-Nov. 12.) 7000 w.

*26794. The Merrifield-Westcott-Pearson (Improved Lowe) Carburetted Water-Gas Apparatus, with Editorial. Ill. (J G L-Nov. 6.) 3300 w.

*26795. The Question of Economical Gas Enrichment. Alexander C. Humphreys and A. G. Glasgow (J G L-Nov. 6.) 1000 w.

26806. Patching Holders While in Use. Ill. J. H. Findlay (P A-Nov. 15.) 600 w.

26808. Some Experiences with the Welsbach Incandescent Gas Lamp. W. S. Rathell (P A-Nov. 15.) 2500 w.

26896. Light Wasted in Bad Flames. Ill. N. W. Gifford (A G L J-Nov. 19.) 1200 w.

26897. The Use of Gas for Other Purposes Than Lighting. Burdett Loomis (A G L J-Nov. 19.) 2600 w.

26898. A Small Experimental Plant as an Aid to the Management of a Coal Gas Plant. Peter Young (A G L J-Nov. 19.) 1300 w.

*27064. Notes on Coin Meters. Frank Livesey, with Discussion (J G L-Nov. 13.) 5200 w.

*27065. The Use of Charging and Drawing Machinery in Small and Medium-Sized Gas-Works. Ill. J. T. Lewis, with Discussion (J G L-Nov. 13.) 4000 w.

*27168. The Danger of Modern Gasholder Practice (J G L-Nov. 20.) 2000 w.

*27171. The Gas Industry in the United States. H. Bunte (J G L-Nov. 20.) 2500 w.

*27295. Artificial Illumination in Theory and Practice. Carlton Lambert (P Eng-Nov. 23.) 2200 w.

*27330. A New Motor-Gas Process (I C T-Nov. 23.) 1300 w.

*27350. The Design and Construction of Gas-Works for Hot Climates. Lewis T. Wright (G W-Nov. 24.) 1200 w.

27401. Calculations for the Flow of Compressed Air and Gas in Pipes, Simplified. William Cox (A M-Dec. 6.) 1500 w.

Sewerage.

*26706. Teddington Sewage Disposal Works. Ill. Henry York (Eng L-Nov. 2.) 2000 w.

We supply copies of these articles. See introductory.

*26947. Bacteriology of Sewer Air. David Arthur (S R-Nov. 10.) 2000 w.

*26954. The Utilization and Purification of Sewage. Editorial (Eng L-Nov. 9.) 2700 w.

†26955. Teddington Sewage Works. Ill. (Eng L-Nov. 9) 500 w.

27045. Some Sewer Details. Ill. A. P. Folwell (E R-Nov. 24.) 900 w.

Streets and Pavements.

27044. Australian Hard Wood for Pavements. Walter Alexander Smith (E R-Nov. 24.) 1400 w.

27137. The Park Avenue Improvement in New York. Ill. (Sc A-Dec. 1.) 400 w.

*27310. The Physical Properties of Asphalts. Dolphus Torrey (P-Dec.) 1000 w.

*27311. Road Construction in Vermont. (Extract.) Ill. (P-Dec.) 1800 w.

*27312. Paving Brick: Clays and Methods of Manufacture. W. S. Ravenscroft (P-Dec.) 2600 w.

†27314. On the Technical Analysis of Asphaltum. Laura A. Linton (J A C S-Dec.) 3800 w.

27414. The Organization and Work of a Street Department (E N-Dec. 6.) 2800 w.

*27453. Improved Methods in Laying Asphalt Pavements. Clifford Richardson (P-Dec.) 800 w.

Water Supply.

26676. Water Supply System at Madison Barracks, New York. Ill. (E R-Nov. 10.) 1000 w.

26824. The Manchester Thirlmere Waterworks. Ill. (Sc A S-Nov. 17.) 800 w.

26872. How Much Soil Should Be Stripped from Storage Reservoir Beds? Thomas M. Drown (E N-Nov. 15.) 1100 w.

26900. Removal of Iron in a Ground Water Supply (E R-Nov. 17.) 1400 w.

27022. Water Supply from Saturated Beds of Sand and Gravel (E N-Nov. 22.) 1700 w.

*27169. Sir R. Rawlinson on the London Water Question. (Abstract.) (J G L-Nov. 20.) 1000 w.

†27239. The Color of Water. Desmond Fitz Gerald and William E. Foss (J F I-Dec.) 3000 w.

27415. Experts' Report on the Reservoir Failure at Lancaster, Pa. Henry Leffmann (E N-Dec. 6.) 1500 w.

†27449. Drinking Water in Its Relation to Malarial Diseases. Richard H. Lewis (San-Dec.) 11000 w.

Miscellany.

*26664. Planning the Site for a City. Lewis M. Haupt (E Mag-Jan.) 3000 w.

26677. Water Supply and Sewage Disposal in Some Large European Cities. J. S. Billings (E R-Nov. 10.) 5800 w.

26819. Municipal Electric Lighting. E. Carl Breithaupt (C Eng-Nov.) 3000 w.

*26830. Organization and Management of a City Engineer's Office.—A Symposium. I. Introductory. Albert F. Noyes. II. The City Engineer's Office, Providence, R. I. Otis F. Clapp. III. City Surveys. W. E. McClintock. IV. Survey of the City of Lowell for Assessors' Maps. G. A. Nelson. V. The Relation of the City Engineer to Public Parks. John C. Olmstead. VI. Water Works.—Office Records. Dexter Brackett. VII. Municipal Engineering in Haverhill, Mass. J. T. Desmond (J A E S-Oct.) 32000 w.

26854. Hamburg Disinfecting Establishment. W. H. Robertson (A An-Nov. 15.) 1200 w.

26948. Park Boards and Their Professional Advisers (G & F-Nov. 21.) 1600 w.

27177. The Thackeray Garbage Incinerator for the City of Montreal. Ill. (E N-Nov. 29.) 1600 w.

27178. The Report of the New York Garbage Commission (E N-Nov. 29.) 900 w.

27420. Organization of a City Engineer's Office (E N-Dec. 6.) 2300 w.

27421. Organization and Management of a City Engineer's Office. (Abstracts of papers published in the Journal of the Association of Engineering Societies.) (E N-Dec. 6.) 1800 w.

Serials.

5358. Sewage Purification in America (E N-Began July 14, 1892—43 parts to date—15 cts. each).

14839. Water Purification in America (E N-Began Aug. 3, 1893—15 parts to date—15 cts. each).

23641. Details of Rural Water Supply. Ill. (B-Began July 7—16 parts to date—30 cts. each).

24751. The Gas Manager Abroad (G W-Began Aug. 25—9 parts to date—30 cts. each).

26096. Notes on Modern Gas-Making Plant (I & I-Began Oct. 12—4 parts to date—30 cts. each).

26221. The Manchester Thirlmere Water Works (Eng L-Began Oct. 19—2 parts to date—30 cts. each).

26436. Gas Manufacture. J. J. Johnson (C T J-Began Oct. 27—Ended Nov. 3—2 parts—30 cts. each).

26496. Construction and Working of Regenerator Settings of Retorts. Ill. W. R. Chester (A M & I W-Began Nov. 2—2 parts to date—15 cts. each).

26807. The Gas Industry of To-day (P A-Began Nov. 15—Ended Dec. 1—2 parts—15 cts. each).

26999. Three-Lift Gasholder at the Glasgow Corporation Works (E-Began Nov. 9—Ended Nov. 16—2 parts—30 cts. each).

27075. Wells and Subterranean Water Supply. William D'H. Washington (F W-Began Nov. 24—2 parts to date—15 cts. each).

27272. The Construction of the New Syracuse Water Works. Ill. (E R-Began Dec. 1—1 part to date—30 cts).

We supply copies of these articles. See introductory.

RAILROADING

Prevention of Train Robberies—The Caldwell Bill.

A COMMUNICATION from Mr. Charles L. Loop, general auditor Southern Express Company, to the *Railway Age* (Nov. 9) strongly favors the passage of what is known as the Caldwell bill, introduced in the house of representatives Sept. 16, 1893. The text of the bill, which it seems might be improved in point of grammatical construction, is given below.

SEC. 1. Be it enacted by the senate and house of representatives of the United States of America in congress assembled, that any person or persons who wilfully and maliciously displaces or removes a railway switch, cross-tie, or rail, or injures a railroad track or bridge, or does or causes to be done an act whereby a locomotive, car, or train of cars, or any matter or thing appertaining thereto, is stopped, obstructed, or injured, with intent to rob or injure the person or property passing over any railroad engaged in insterstate commerce, and in consequence thereof a person is killed, shall be guilty of murder.

SEC. 2. That any person or persons who wilfully and maliciously displaces or removes a railway switch, cross-tie, or rail, or injures a railroad track or railroad bridge, or places an obstruction on such track or bridge, or unlawfully and maliciously displays, hides, or removes a signal or light upon or near to a railroad, or unlawfully and maliciously does or causes to be done anything with intent to rob or to injure a person or property passing over such railroad engaged in interstate commerce, shall, on conviction, be imprisoned at hard labor not less than one nor more than twenty years.

SEC. 3. That any person or persons who unlawfully or maliciously throws or causes anything to be thrown, or to fall into or upon or to strike against a railroad train, or an engine, tender, car, or truck, with intent to rob or to injure a person or property on such train, engine, car or truck engaged in interstate commerce, shall, upon conviction, be imprisoned at hard labor not less than one year nor more than twenty yesrs.

SEC. 4. That the circuit and district courts of the United States are hereby invested with full and concurrent jurisdiction of all causes or crimes arising under any of the provisions of this act.

In the support of the measure Mr. Loop makes use of the strong argument that the very next step in train-robbing will be the looting of passengers. The suggestions of plans of inventions of burglar-proof cars, of schemes for asphyxiating train robbers, etc., have been as plentiful as the typically numerous car couplers, but any scheme for a traveling fortification is as impracticable as it would be for any person to go habitually clad in armor to prevent assassination or highway robbery. The greatest protection against train robbery must exist in public sentiment, or in fear of the law. That the train robbers do not fear the law is evidenced by their increasing number. That the express companies do take precautions to prevent robbery goes without saying, although their means is not necessarily for publication. It is a matter of fact, in which all express companies will doubtless concur, that the amounts expended in the efforts to detect, apprehend, and convict train robbers far exceed the amount of money actually lost by the robberies."

It is thus seen that the suggestions made in some quarters that the express companies run burglar proof cars, is not regarded as affording a solution of the problem. A reason assigned for the rapid increase of this crime is newspaper exaggeration of the amounts stolen. "For example, the recent robbery of the Adams Express Company on the R. F. & P. R. was heralded all over the country as involving a loss of $180,000, whereas one-tenth of the amount would have been a more accurate statement. Vicious per-

sons, not previously guilty of highway robbery are led by reading these circumstantial accounts of robberies and the extraordinary amounts presumed to have been taken, to consider with what ease and facility they may suddenly enrich themselves."

It is, moreover, urged that "the low rates received by express companies for the transportation of money would not be any compensation for the extraordinary expense that might be necessary to manufacture and haul burglar-proof cars."

The provision in section 4 of the bill, it is stated, has excited "some opposition on account of state rights." It would seem that in a matter of such national importance, such a consideration should be set aside, and that some measure at least as stringent as the proposed bill should be enacted.

The Puzzles of Rate Making.

UNDER this title *The Railroad Gazette* editorially discusses the answer of the Louisville and Nashville road "in the suit of the Cincinnati Freight Bureau to compel the road to reduce rates from Cincinnati to southern cities, as ordered by the Interstate Commerce Commission," and also "the answer of the Northern Pacific and the Great Northern to an order of the railroad commissioners of North Dakota requiring those roads to reduce their rates on coal." Both these documents exemplify the difficulties that beset the subject of "rate-making."

"The points in the argument of counsel are numerous. Lawyers are noted for adducing innumerable reasons why their client should not be made to suffer; but while as a rule nine-tenths of such reasons may be nothing but sawdust, when it comes to freight rate-making, in a country grid-ironed with railroads, this rule does not hold good; there the lawyer who sets out to 'stump' the judge or jury does not have to rake up whimsical arguments, for he has enough good ones. Any one who thinks rate-making is simple work can learn a good deal from the two cases we refer to."

"The pith of the defense" made by counsel for the Louisville and Nashville road is that the commission has made a mistake in adjusting rates over this road from Chicago by those from New York, which have to be reduced to compete with the low water rates southward from New York along the Atlantic Coast.

"It is obvious that no human being is competent to fairly consider all the elements in a comparison of all the claims of Chicago and New York when they are competing for the sale of a box of soap in Alabama." In their answer counsel also allege that "cost per ton-mile is not a just measure of reasonableness of rates" and the commission is regarded as "here again treading on insecure ground."

"The average cost per ton is so affected by the kind of freight that a road hauls most of, that this argument is probably no whit better than to take the granger's original and all-embracing claim: 'you are making too much money and we propose to have make you make less.'"

It is finally alleged that "in naming rates to a number of cities and requiring the road to go on and follow out the same rule in making tariffs for other cities not named, the commission asks an impossibility." This claim of counsel, is viewed as technical only, as it is thought that if the road in question made in good faith an effort to carry out the requirements, the commission would be satisfied with their best efforts, not exacting what can clearly be shown to be an impossibility.

Sharp Flanges.

"A SHARP flange," says the *Street Railway Journal* for December, "may be technically defined as one in which the part of the flange next the rail has become vertical. The extent of this vertical surface or its depth may be said to determine the degree of sharpness which does not, as might be supposed, necessitate a razor edge upon the flange. Another definition of a sharp flange would be a wheel in which the flange is so worn as to be without flare. A sharp flange mounts the rail with extreme ease, regardless of the actual depth of the flange itself, and hence is always likely to produce a derailment from the most trifling cause.

The reason for this is not at once evident. With a vertical side the five-eighths flange of an ordinary thirty-inch wheel will touch the rail for four and a half inches in advance of the point of contact between wheel tread and the rail. The whole of this surface is an actual grinding contact with a rail of ordinary section. The result is a powerful lifting action, greatly aggravated by any side motion, by dirt or other obstruction. In this way, the forward revolution of the wheel is constantly tending to throw the car from the track. A very similar case, which all who are familiar with steam engines will call to mind, illustrates the point; it is the ease with which a governor belt jumps off from the double flanged pulleys on which it runs. These pulleys have vertical flanges, often of considerable depth." This state of a wheel, which is considered as very dangerous, is illustrated in the diagram reproduced from the journal quoted, which also asserts that no other defect is more likely to produce accidents.

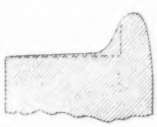


FIG. 1.—OUTLINE OF FULL AND OF SHARP FLANGES.

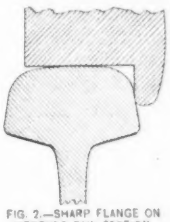


FIG. 2.—SHARP FLANGE ON IMPROVED RAIL SECTION.

One cause early assigned for this defect, was that the two wheels being put on the axle without regard to their roundness or equality of size just as they came from the foundry, and one being softer than the other, the soft wheel in some way or other acquired the shape indicated. Difference in diameter would tend to cause "one wheel to run forward," and thus "force the opposite wheel against the rail." But in modern practice great care is taken to size the wheels accurately and hence this cause can no longer be considered valid. "The diameters of two wheels on the same axle are practically obtained to within the thirtieth of an inch.

"'Trucks out of square,' or a want of parellelism between the two axles of a truck, is now considered one of the most frequent causes for sharp flanges. At least, recent experiments point to this as the case. If squaring gages are not carefully used, this is often an unexpected cause. Even by the employment of gages it is not always easy to determine the absolute parallelism of the axles, nor can it always be established that they are also at right angles to the rails. It may also happen that, while the axles are at right angles to the track, and parallel to each other, the wheels do not 'track' properly. In other words, while the axles form with the side bars of the truck the four sides of a parallelogram, it is not rectangular. In such cases the diagonal distances from tread to tread will not be equal. In trucks without attached bodies, gages from center to center of brasses can be used for the purpose of testing this point.

"Trucks that start square in the world not infrequently become distorted by severe usage, in accidents, etc. On steam roads such distortion was not uncommon. But as the gaging was by no means as difficult as on the street railways, there was little excuse for such a condition. On street cars, the difficulty of tracing this want of parallelism in the axles becomes very great, and much of the trouble of sharp flanges undoubtedly might be avoided could this one cause be more carefully controlled."

However, if a remedy can be found it is not worth while to speculate at length upon the occult causes of the defect, although remedies, when their action is well understood, ought to suggest causes, and this appears to have been the result. The chief cause is now considered to lie in a faulty shape of the head of the rail. The wheel tends to assume a form according with that of the rail. "Some years ago, several steam roads in this country, in investigating this subject, came to the conclusion that if the corner of the rail was not sharp enough to cut a groove in the wheel, sharp flanges would not result. In other words, they believed that the wheel wearing against the rail finally took the form of the rail head. Acting upon this, a rail head was designed,

which should more nearly fit the ordinary form of wheel when new. An outline of this head is shown in Figure 2. The dotted outline shows how the sharp flanged wheel, in Figure 1, would ride upon such a rail, and it also clearly proves that such a rail is incapable of wearing a wheel into any such form as that shown in the first figure. In a word, the theory was that though there might be numberless reasons to determine the cutting, yet if the cutting member is so shaped or formed as to make an effectual barrier against the production of the undesirable form of wheel, the trouble will be avoided, and sharp flanges become a thing of the past. Several roads adopted the form of rails shown, and with the most satisfactory results."

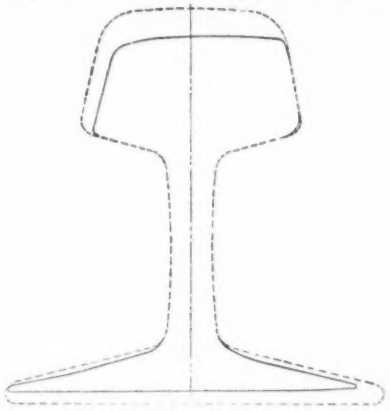
Subsequent investigation has proved the soundness of this view, and the adequacy of the remedy applied. It may be laid down as a principle in mechanics, that where mutual wear takes place between the surfaces, that which under the existing conditions must wear the more rapidly will gradually approximate in form to that which wears least. In this principle is not only indicated the cause but the remedy for sharp flanges.

Corrosion of Rails in Tunnels.

A REMARKABLE example of corrosion of a rail in Musconetcong tunnel on the Lehigh Valley railroad, is illustrated in the accompanying diagram which accompanied a description of the same in the *Railroad Gazette* (Nov. 23). It is almost incredible that all this damage should have resulted in the time the rail was in the tunnel, but facts are stubborn things. "The section shown in dotted lines is the original from the rail; the full lines show the loss of material by corrosion." It was originally a 76-pound steel rail. The diagram is to a scale $\frac{1}{2}'' = 1''$

"The rail had been in the track five years. It will be observed that much the greatest loss by corrosion is in the bottom flanges, the loss from the top and running side of the head is of course from wear. It seems a curious circumstance that the loss was so largely from the under side of the flange. There is little diminution of the thickness of the web, and the under side of the head seems to have lost very little.

"From E. J. Dorsey, supervisor, we have ascertained that there can be no question about the two sections having originally been alike. The worn section was cut from a rail where it rested on a tin plate, but the same results are shown where the rail was on the tie itself. The roadbed is practically solid rock bottom, and it is impossible to change the surface on account of the limited space. The track has therefore little or no elasticity. The tunnel is very wet and the rails slippery and a good



CORROSION OF RAILS IN TUNNELS.

deal of sand must be used. This collects along the rail and works underneath the base, adding no doubt, to the wear by friction between the rail and the tie or tie plate. This influence, acting with the corrosion caused by the gases, wears the rails out very fast."

Is it not possible that, issuing from the rock in the tunnel there may be some gas of an acid character that has aided in the rapid destruction of the rail? If there is so much drip in the tunnel, the water absorbing such a gas would become a very active reagent. Is it not also possible that as a part of the rail rests on a tin plate a certain amount of galvanic action is set up throughout the entire length of the rail? Such action, if set up, would not be likely to be confined to the near vicinity of the tin plate.

Car Lighting.

THE subject of car lighting with reference to its influence upon the passenger traffic of competing roads, and as related to the comfort of travelers who patronize railways, is well discussed by a correspondent of *The Railway Review*. The traveling public demand some better and safer method of car-lighting than kerosene lamps. It is urged that "the day has gone by when passengers will longer be satisfied to make long or short after-dark journeys in poorly lighted cars. The long dissatisfaction on this score has been much enhanced by the fact that one-sixth of the passenger, mail and sleeping cars now running on American roads are lighted by Pintsch gas, and most people who travel have made a few journeys in cars thus lighted, and they have thus learned that cars can be well and safely lighted. This has made them less patient with the ancient kerosene contrivances which still prevail on many roads, and as a consequence the roads running the best lighted cars get most of the after-dark travel. This was demonstrated on the Broadway and the Third avenue roads of New York when they put in Pintsch lights. Three lamps to a car were used, with four burners to a lamp. The resulting growth of traffic was both rapid and permanent; thousands of people who had previously ridden in the kerosene lighted cars of the Manhattan elevated railway, immediately changed to the well lighted cable cars, where their eyes were not strained to read their papers."

The writer of this protest claims to have been a considerable night traveler by rail and also a very considerable reader, and he speaks from experience of the great annoyance that attends the use of badly trimmed, frequently smoking, and always foul-smelling kerosene lamps with which the majority of cars are lighted. As to electricity, it is doubtful that it will ever be extensively used for car-lighting except on electrically operated railways, and hence gas, which has long been proved the best car illuminant yet discovered will doubtless ultimately become the chief resort for this purpose. The danger in the use of kerosene as a source of fire in wrecked trains is pointed out, although this seems much less than that attending the use of stoves, which has been largely abandoned. To substantiate the claim of danger in the use of kerosene lamps, a number of cases of destruction by fire of mail cars alleged to have been thus caused are cited.

Strategic Mountain Railways.

THE term "strategic" has been applied to railways which were not wholly designed for military purposes in time of need, being used for ordinary traffic in time of peace, but which are, however, specially located and adapted for military service in time of war. Among the more remarkable of these are such as are specially intended to facilitate mobilization of troops over mountain ranges. An enumeration of the latter, and a description of their leading features form the subject of a serial begun in *Engineering* (London, Nov. 2), and written by C. S. Du Riche Preller, who has recently inspected some of the more important examples of railways with steep inclines.

In the category of "strategic mountain railways," are not included such lines as the Mont Cenis, St. Gothard, Arlberg, Brenner and Semmering, though in time of war these would be important lines of military communication; they are properly to be considered as great international highways, and as such form a category apart.

"On the other hand, some of the mountain trunk railways of Switzerland, no less than a similar line recently opened in Japan, may fairly be included, for although not, perhaps, of immediate or paramount strategic interest, they yet form important links in the defensive communications of these two countries, while, in time of peace, they serve, in common with the other lines, the purposes of ordinary traffic. The railways to be briefly considered are therefore, those of Usui Pass in Japan, the Black Forest, the Höll Valley, and the Waldshut and Impendingen (Buchberg Pass) in the Grand Duchy of Baden, South Germany; the South-Eastern (Alt-

matt Pass) in Switzerland, and the Sarajevo and Konjica line (Ivan Pass) in Bosnia and Herzegovina."

Particulars of the Usui Pass railway in Japan, opened last year, are at present of much interest, as the attention of the world is now centered on that remarkable country.

"The line is on the 3.5-foot gage, and the incline is laid with treble 20 millimeter, Abt, rack, steel bars. As Mr. Pownall rightly observes, the incline is essentially what Mark Twain would call 'a railway decorated with tunnels,' there being in the total length of five miles no less than 26 tunnels, of an aggregate length of 2.6 miles. It might be added that it is also a railway 'decorated with bridges,' for of these there are no less than 34 in number. The total rise is 1573 feet and the gradient is nearly uniform, viz., 1 in 15, or 6.66 per cent., while the curvature is comparatively easy, the minimum radius being 13 chains. The permanent way, laid with steel sleepers, is of a very substantial character. The whole line is worked with Abt adhesion and rack or so-called 'combination' engines, built at the locomotive works of Kessler & Co., Essligen, Wurtemberg. The first engines sent out, of about 36 tons (10 tons tractive power and 260 horse-power), are now being replaced by a more powerful type of 50 tons, capable of hauling, under the indifferent conditions of adhesion in the tunnels, a load of 100 tons at five miles per hour."

In South Germany, of the mountain lines classed above as strategic, the Waldshut and Impendigen railway is regarded as a typical railway of this kind, although descriptions of the others are given. It is the most costly of all the German railways, "a strategic mountain railway in the strict sense of the term, with long sidings at every station for military trains. . . The stipulated gradient of one per cent. on the mountain section, viz., on the divide of the Rhine and Danube watersheds formed by the Buchberg necessitated an extensive development of the line by means of an extraordinary series of serpentines and helicoidal or spiral tunnels . . . which render the line one of the most remarkable of its kind." There are six of these tunnels aggregating three miles in length, and four viaducts, all in a distance of sixteen miles. The total cost of the line (47 miles) is stated to have been $4,356,000.

Railroad Cars and Practice in England.

RETURNING from a trip in "the old country" to the United States, Mr. Edward Webb, foreman of one of the departments of the Laconia Car Company thinks his impressions of English cars, and of English railway practice in general, may prove of interest to American readers. Accordingly, in the *Railroad Car Journal* for November, he prefaces an account of what he recently saw with a statement that he left England when a young man (1859), and then makes a comparison between the status of things in railway practice as it was more than thirty years ago, with what is now in vogue.

Admitting that he sees things differently after thirty years' familiarity with railway appliances than when in adolescence he left England and came to the United States, he says the railway cars of to-day look to him very much as they did at the former date, and that though they must, in the nature of things, have shared somewhat in the general onward progress, "an English car is an English car, and you cannot look at it in any other light," and that "no American traveler in England can fail to notice the difference between English and American cars.

"The baggage arrangements would drive an American nearly crazy. A first-class passenger is allowed 120 pounds, third class, 60 pounds. He has to look after it himself, no checks being given; so if you are going a long journey and have to make three changes of trains, which is not impossible, you have the pleasure of three times going up to the baggage car at the station where you 'change' and hunt for your baggage. If baggage is left at the station it must be booked and paid for at the rate of four cents on each piece. This secures it for 48 hours; after that time there is a storage charge of two cents each day for each piece. The company is only responsible for 'booked' baggage.

INDEX TO LEADING ARTICLES.

The journals quoted are indicated by initials, and their full titles are given in the opening pages of the Review. Other abbreviations are, Ill=Illustrated; W=Words.

25956. Street Railway Repairs. J. B. Cahoon (E W-Oct. 20.) 5000 w.

26402. The Puzzles of Rate-Making. Editorial (R G-Nov. 2.) 1800 w.

*26666. Half yearly Meeting of the Grand Trunk Railway of Canada. Address of President Henry W. Tyler, with Discussion and Editorial (Ry T-Nov. 3.) 7000 w.

26669. Cost of Power in Car Shops. James F. Hobart (R C J-Nov.) 600 w.

26671. Railroad Cars and Railroad Practice in England. Edward Webb (R C J-Nov) 1200 w.

26672. Car Cleaning. Report of Committee, with Discussion (R C J-Nov.) 1600 w.

*26680. The Railway Year in Queensland (Tr-Nov. 2) 1800 w.

*26686. Report of the Special Committee on Light Railways for Agricultural Purposes (I C T-Nov. 2.) 5000 w.

*26702. Express Passenger Locomotives, Great Western Railway. Ill. (Eng L-Nov. 2.) 1000 w.

*26707. The Board of Trade and Light Railways. Editorial (Eng L-Nov. 2.) 1700 w.

*26713. The Board of Trade and Light Railways. Editorial (E-Nov. 2.) 3000 w.

*26716. The Alleged Lock and Block Failure at Baker Street Station. Ill. (E-Nov. 2) 1800 w.

26730. Storage Battery Traction. Pedro G. Salom (S R G-Nov. 10.) 1000 w.

26731. Interference with Street Railway Traffic. R. D. Fisher (S R G-Nov. 10.) 1500 w.

*26737. The St. Gothard Railway. Ill. (R W-Nov.) 2000 w.

*26738. Some Railway and Tramway Exhibits at the Antwerp Exhibition. Ill. H. Conradi (R W-Nov.) 2600 w.

*26740. The Northallerton Accident and Its Lesson. Ill. (R W-Nov.) 800 w.

*26747. Electric Fog-Signalling on Railways (E L-Nov. 2.) 1000 w.

26766. Prevention of Train Robberies—The Caldwell Bill. Charles L. Loop (R A-Nov. 9.) 900 w.

26784. Car Lighting. W. A. T. (R R-Nov. 10.) 800 w.

26785. Live Stock Rates. Editorial (R R-Nov. 10.) 1000 w.

26786. Heating of Large Railway Buildings. Editorial. (R R-Nov. 10) 900 w.

26788. Cinder Pits.—Report of Committee. Presented by W. G. Berg, Chairman (R R—Nov. 10) 3000 w.

26793. Is There a Solution of the Electric Conduit Railway Problem? (Abstract.) Joseph Sachs (E R N Y-Nov. 14.) 3000 w.

*26813. Train Lighting by Electricity on the Danish State Railways (M W-Nov. 9.) 600 w.

26817. Railway Building Across Peat Bogs (C Eng-Nov.) 900 w.

*26832. Road Test of a Modern Ten-Wheel Freight and Passenger Locomotive. W. G. Kranz and J. B. Turner (S J E-Oct.) 1000 w.

26867. The Value of Branch Lines of Railway (E N-Nov. 15.) 800 w.

26870. How the New York Rapid Transit Railway Will Be Built (E N-Nov. 15.) 1600 w.

26874. Draft Rigging Between Floor Sills of Freight Cars. Ill. (R G-Nov. 16.) 1500 w.

26875. The Economical Load for Locomotives. Charles Paine (R G-Nov. 16.) 600 w.

26876. State Railroad Control in Texas. Editorial (R G-Nov. 16.) 1800 w.

*26878. Construction and Operation of Small Street Railways. W. Worth Bean (S R R-Nov.) 1200 w.

*26879. A Comparison of Rheostat and Series—Parallel Control (S R R-Nov.) 400 w.

*26881. The Evolution of Electric Traction. William Clinton Burling (S R R-Nov.) 2800 w.

*26883. New Plant of the Chicago General Railway. Ill. (S R R-Nov.) 900 w.

26903. East Boston Electric Railway Power Station (E R-Nov. 17.) 1600 w.

26931. Areas of Contact between Wheels and Rails. Ill. (R R-Nov. 17.) 700 w.

26933. Economies in the Telegraph Departments of Railways. Editorial (R R-Nov. 17.) 1000 w.

*26946. Light Railway Development (I & S-Nov. 10.) 4500 w.

*26953. English and American Locomotives in the Argentine Republic. Editorial (Eng L-Nov. 9.) 2000 w.

27005. The Electric Railway System of Toronto, Canada. Ill. (E E N Y-Nov. 21.) 1800 w.

27031. Improvement of Block Working. C. C. Anthony (R G-Nov. 23.) 1200 w.

27033. Hydraulic Tools and Plant in French Car Shops. Ill. (R G-Nov. 23) 1400 w.

27034. The Economics of Lubrication. Editorial (R G-Nov. 23.) 1000 w.

27035. The Elevated Railroads in New York. Editorial (R G-Nov. 23.) 1000 w.

*27042. Light Railways for Farmers. Editorial (Eng L-Nov. 16.) 1800 w.

27076. The Ridgewood Power Station, Brooklyn. Ill. (S R G-Nov. 24.) 1000 w.

*27077. Light Railway Problems. Editorial (Ry T-Nov. 17.) 1000 w.

*27090. Electric Traction on Street Tramways. Editorial (E-Nov. 16) 2200 w.

*27092. The International Railway Congress (E-Nov. 16.) 1300 w.

*27125. The Progress of Electric Traction in Germany (E R L-Nov. 16.) 800 w.

We supply copies of these articles. See introductory.

†27153. Notes on Unit Stresses for Railroad Bridges of Wrought Iron. Silas G. Comfort, with Discussion (P E C P-Nov.) 4000 w.

27158. History of Freight and Passenger Terminals at St. Louis (R G-Nov. 30.) 2200 w.

27159. A Bridge Built of Old Rails. Ill. (R G-Nov. 30.) 800 w.

27161. English Signal Practice. F. A. Delano, with Editorial (R G-Nov. 30.) 7000 w.

27162. The Elevated Railroad Loop Situation in Chicago. Editorial (R G-Nov. 30.) 1800 w.

27175. Shall Freight be Handled on the New York Rapid Transit Railway? (E N-Nov. 29.) 2000 w.

27176. Power House and Electric Locomotives for the Baltimore Belt Railway. Ill. (E N-Nov. 29.) 2000 w.

27179. The Webber Combined Brake and Fender for Street Cars. Ill. (E N-Nov. 29.) 900 w.

27207. Notes on Economy Tests of Electric Railway Plants. George H. Davis (E W-Dec. 1.) 2500 w.

27208. The Sag in Span and Trolley Wires. E. A. Merrill (E W-Dec. 1.) 1000 w.

†27215. Brigandage on Our Railroads. Wade Hampton (N A R-Dec.) 1500 w.

†27227. Present and Prospective Development of Electric Tramways. C. J. Field (A S M E-Dec.) 5200 w.

†27237. Strength of Railway Car-Axles. L. S. Randolph (A S M E-Dec.) 1200 w.

27254. Lenox Avenue Conduit Construction, New York. Ill. (S R G-Dec. 1) 600 w.

27255. Franchises. R. D. Fisher (S R G-Dec. 1.) 2000 w.

*27268. The Great Northern Railway Company's Goods Depot, Farringdon Road. Ill. (Eng L-Nov. 23.) 3500 w.

*27281. Going Through Normandy. Ill. A. S. (L E-Dec.) 3300 w.

*27282. Block Signaling on the New York Central Railroad. D. B. McCoy (L E-Dec.) 1700 w.

*27284. The Past and Present of Car Ventilation (L E-Dec.) 1100 w.

*27285. How Rail Joints May be Made. Ill. Joseph Anthony (L E-Dec.) 1400 w.

*27287. Cleaning of Passenger Cars (L E-Dec.) 600 w.

*27337. Electrical Steep-Grade Traction in Europe. C. S. Du Riche Preller, with Discussion (E E L-Nov. 23.) 4800 w.

*27338. Notes on the Different Kinds of Processes Used on the European Continent for Preventing Incrustations in Locomotive Boilers (N C B-Dec.) 1000 w.

*27339. Railway Coach Varnishing. J. H. Pitard (N C B-Dec.) 1200 w.

*27340. Some Economical Characteristics of Locomotive Injectors. Strickland L. Kneass (N C B-Dec.) 1500 w.

*27363. The Light Railway Question (Tr-Nov. 23.) 2000 w.

*27364. State Subsidies to Light Railways (Tr-Nov. 23.) 2300 w.

†27383. The Street Railways of Washington, D. C. Ill. (S R J-Dec.) 5800 w.

†27384. The Wyoming Valley Interurban Railway. Ill. (S R J-Dec.) 3000 w.

†27385. Some Details of the Electrical Railway Work of the New Orleans Traction Company. Ill. W. Nelson Smith (S R J-Dec.) 1700 w.

†27386. Underground Electric Railways in London. Alex. McCallum (S R J-Dec.) 2200 w.

†27387. Sharp Flanges (S R J-Dec.) 2300 w.

†27388. Motor Repairs. Ill. James F. Hobart (S R J-Dec.) 1400 w.

†27389. Notes on Power Station Economy. George H. Davis (S R J-Dec.) 1800 w.

†27408. Rubber as a Factor in Safety on Railways (I R W-Dec. 10.) 1000 w.

27426. Some Lessons of the Scrap Pile. (Synopsis.) J. N. Barr (R G-Dec. 7.) 1600 w.

27427. The M. C. B. Coupler in 1894.—Discussion of Paper by A. M. Waitt (R G-Dec. 7.) 4000 w.

27428. The Proposed M. C. B. Coupler Tests. Editorial (R G-Dec. 7.) 1600 w.

Serials.

22639. A Master Car Builder's Reminiscences. John Kirby (R C J-Began June—4 parts to date—15 cts. each).

24586. Railway Companies and Their Employés. Ossian D. Ashley (R A-Began Aug. 24—5 parts to date—15 cts. each).

24621. Rules and Instructions for the Guidance of Railway Agents (R R-Began Aug. 25—14 parts to date—15 cts. each).

25348. Mechanical Traction for Tramways (E E L-Began Sept. 14—Ended Nov. 16—5 parts—30 cts. each).

25599. Notes on the Management of Railway Power Stations. George T. Hanchett (E W-Began Oct. 6—9 parts to date—15 cts. each).

26554. The General Theory of Rates. Charles H Cooley (R R-Began Nov. 3—Ended Nov. 10—2 parts—15 cts each).

25954. Electric System of the Philadelphia Traction Company. Ill. Hermann S. Hering (E W-Began Oct. 20—Ended Nov. 10—4 parts—15 cts. each).

26525. The Liverpool Overhead Railway (E R L-Began Oct. 26—Ended Nov. 2—2 parts—30 cts. each).

26711. On Strategic Mountain Railways. Ill. C. S. Du Riche Preller (E-Began Nov. 2—Ended Nov. 23—3 parts—30 cts. each).

26989. Electric Traction, with Special Reference to the Installation of Elevated Conductors. Robert W. Blackwell and Philip Dawson (El-Began Nov. 9—2 parts to date—30 cts. each).

27091. The Manchester and Sheffield Railway Extension to London. Ill. (E-Began Nov. 16—1 part to date—30 cts).

We supply copies of these articles. See introductory.

SCIENTIFIC MISCELLANY

Suggestions for an Index for Technical Literature.

THE pressing need for an index of the kind named in the title, a brief history of the attempts made to supply it (most of which have failed to give what the public wants, while a number have been discontinued for want of financial support), and suggestions for an index that shall "avoid the failings of those already existent," are topics treated in a paper by Prof. George D. Shepardson in the *Transactions of the American Institute of Electrical Engineers* for November. The paper demonstrates that while it is not very difficult for any man to state his particular idea of what an index of technical literature ought to be, it has not been an easy matter to supply just what is wanted by the public. No one has yet been found to publish such an index solely out of a desire to benefit technical students and readers, and no one, until this magazine evolved it, has been able to produce such an one as would draw to it a substantial financial support. As well known, we began this index tentatively, and by feeling the public pulse, so to speak, we have been able to gage our progress toward that form which on the whole, as the demand for it compels us to believe, meets with wider approbation than any other. This effort has involved an amount of labor, to say nothing of expense, which few would be prepared to appreciate. The following are some of the attempts that have been made in this line as named by Prof. Shepardson.

"Perhaps the greatest of these is the 'Royal Society Catalogue of Scientific Papers,' consisting of eight quarto volumes of about 1000 pages each. This was compiled under the auspices of the Royal Society of England, and was printed by the English government at public expense. It gives alphabetical lists of titles and authors of scientific papers published in every civilized country, between the years 1800 and 1873, but exclusive of technical and professional papers." Prof. Shepardson thinks next to this stands Poole's Index of Current Literature, published in this country by private enterprise. The first volume, compiled with the coöperation of 52 libraries, indexed 6200 volumes which were published during the period from 1803 to 1882 and contains about 1000 references to articles on electrical subjects that appeared in popular and scientific journals. The second volume, to which 97 libraries contributed, covers the period from 1882 to 1887, and contains about 600 references to articles on electrical subjects. The third volume, compiled with the coöperation of 122 libraries, covers the period from 1887 to 1892, and gives about 500 references to electrical papers. The volume for 1893 gives about 100 such references. In Poole's Index there is some attempt at classification of electrical papers and there are a few cross references.

"The Descriptive Index of Current Engineering Literature, compiled from the monthly summaries in the Journal of the Association of Engineering Societies, gives an excellent résumé of engineering literature between 1884 and 1891. This is devoted principally to civil engineering, but gives about 30 pages with 700 references to electrical papers. Most of the references indicate the character of the papers. The cross references are excellent. The index in the Journal of the Association of Engineering Societies is commendable in that it prints the indices on only one side of the leaf, so that they may be cut and rearranged according to the ideas of the individual. The Journal for each December contains a summary of the monthly indices of the year.

"The American Institute of Electrical Engineers published in its Transactions for about three years, 1886 to 1888, an excellent index of current electrical literature compiled gratuitously by a gentleman too modest to have his name appear. Volume v of the Transactions contains about

5100 references, volume vi about 5800, and the first numbers of volume vii contain about 1500 references. Some of these are accompanied by descriptive notes.

"The first volume of Galloupe's *Engineering Index*, compiled and published by private enterprise, gives about 28 pages with 1500 references to articles on electrical subjects appearing in the years 1883 to 1887. The second volume, 1888 to 1892, gives 61 pages with about 3300 references, titles and authors being given.

"Excellent indexes have appeared in THE ENGINEERING MAGAZINE and in *Electrical Engineering*, the figures for which are not at hand. Recently *Electric Power* has launched out into this field. The digest of foreign literature in the *Electrical World* is commendable, but confessedly incomplete. Extended indexes are published at intervals by the French and Germans. A universal index, published weekly at Leipzig, aims to give tables of contents of a number of journals arranged in the alphabetical order of their places of publication. Doubtless there are other indices not known to the present writer.

"To the mind of the writer, the most ideal index yet attempted was that published at first in connection with *Electrical Engineering* and later as a too short-lived publication by itself under the name of *Electrical Literature*. The printing of the indexes on separate sheets, perforated and tied together, each sheet being devoted to a single subject, combines the advantage of flexible classification of subjects with ease of arranging the sheets from month to month so as to make the bibliography of each subject consecutive and up to date. Having the sheets loose and perforated for binding with brass clips or cords, allows each individual to supplement the printed sheet by his own notes or additional references. The publisher is also able to add sheets descriptive of later or earlier memoirs without impairing the integrity of previous work. It should be and doubtless is a matter of sincere regret by the electrical and mechanical engineering profession that this publication was forced to suspend on account of lack of financial support.

"Another valuable, but less extensive index was published in the *Electrical World*, vol. xii, p. 6, July 1, 1893, by J. Stanford Brown, giving about 375 references to papers on 'Accumulators in Practical Work.'"

It is evident that the chief obstacles to continued and systematic indexing of technical literature have proved to be insurmountable on any of the lines of which details are above given. Some included too little, others too much. Financial support was lacking undoubtedly because that which was desired in common by a sufficient number was not furnished. That THE ENGINEERING MAGAZINE has been more fortunate in its attempt to do this than others, is due to the fact that a scheme with hard and fast lines was not planned in the outset, but that the present method has been slowly evolved, and its scope extended to meet the ascertained wants of those who patronize it. Not that it has been, or ever will be, possible to suit every one; to attempt this would be even more impracticable than the adoption of a rigid scheme in advance of the knowledge of what is most wanted. But the effort to find out what is wanted by the large majority of readers and to meet this want as nearly as possible, has resulted in the present form of indexing titles, which together with the facilities afforded for obtaining the indexed articles has succeeded beyond the most sanguine expectations. Prof. Shepardson outlines the requirements for a technical index such as would meet his views, as follows:

"It should include subjects relating to electrical, mechanical, hydraulic and civil, and perhaps mining engineering. It should index books as well as periodicals. The references should be descriptive so far as practicable. Each subject should have a page by itself. Digests and simple references might be on separate sheets. References and sheets on some subjects might be numbered consecutively for convenience in adding later notes from other files or from later publications of the same articles. Abbreviations or other symbols should indicate whether the reference is to the original paper or to re-print, whether

the paper is in full or abstract, whether accompanied by discussion and by plates or illustrations. The separate sheets should be perforated for re-arranging and rebinding and should be printed on one side only. It might be preferable to print the whole index of cards similar to those used in the card catalogues of libraries.

"In this way it would be practicable to begin publication at an early date and to issue parts at frequent intervals. The indexes to current publications could be issued without delay, and those of completed files or historical works could appear as the work proceeded. Publishing the work in sections would allow each engineer or student to purchase or subscribe for only such subjects as were of importance or interest to him. Indeed the work, if carried out properly, would result in so massive a catalogue that few outside of libraries or other public institutions could afford to obtain the entire work."

It is frankly admitted that such an index as will be an improvement over existing ones can only be produced by "the coöperation of a large number of people, as was Poole's index to which over 122 libraries contributed," and "that it will require the expenditure of a considerable amount of money, and will probably not be self supporting." Unless some public benefactor shall arise who would be willing to provide a permanent fund to supply deficiencies, the scheme therefore seems visionary and impracticable.

Mental Training—A Remedy for Education.

THIS title indicates something startling. Is education really injurious, that a remedy needs to be supplied for it? William George Jordan, in *The New Science Review*, speaking of "education as we know it to-day," expresses this view. It can scarcely be said to be original with him, since others have not only thought, but publicly expressed the same opinion. The modern system of cram, produces a sort of mental fatness, as the forced feeding of geese fits their livers for the manufacture of pies. Mental alertness, agility, precision, which should result from proper mental training, are replaced by dull perception, sluggishness, inaccuracy.

"There are two things that education should do for the individual—it should train his senses and teach him to think. Education as we know to-day, does not do either; it gives the individual only a vast accumulation of facts, unclassified, undigested, and seen in no true relations. Like seeds kept in a box, they may be retained, but they do not grow. For years the mind is filled with facts that the mind is not trained to digest. To the physical body food is of value only when digested; so it is in the mind with mental food; but if digestion were made continuous, perfect, and ever equal to the supply of food, overfeeding, either in mind or body, would be impossible. But in the education of to-day the digestion is not equal to the feeding."

This is a grave charge, not made as "a criticism of the splendid work of individual teachers, professors, and other educators who have been successful," but directed against the system of modern education. Whatever success these eminent instructors may have had "has been in revolt against conventional machine methods." The object of teaching should be to "quicken, intensify, and develop the working of the mind." It should "train every sense, every faculty, every memory, every power, part and phase of mind, every mental muscle, making it supple and instantly responsive."

This obviously implies that the use of the mind is not analogous to that of a great warehouse, though even in warehouses there is usually some order in the way things are put away, so that they can readily be found when wanted. The mind should be active. It should be as ready to give as to take. Mere passive receptivity never yet was characteristic of mental power.

"With most persons the intellectual brilliancy, the proper thing to say, comes as an afterthought. An afterthought is but a beautiful possibility designed to fit a lost opportunity. It is no more helpful to a man than a flattering epitaph on his tombstone. With most persons this wit is like a night telegram,—it is not delivered

until the next morning. Man expects his hand to be instantly ready to perform any motion of which it is capable; but he is resigned if his mind does not work quickly. He says that readiness is born with people; it cannot be acquired. If a man's heart, lungs, or stomach are weak, he consults specialists, and never gives up until he obtains relief. But if he cannot remember names or faces; if he is subject to that intellectual remorse known as afterthought; if he has no eye for color, or taste for music; if he has no command of language; if there is lack of power in any respect in his mind, he is perfectly resigned, and says, 'I am as God made me, and so I must remain.' When man fails he always does this. He says, 'I am as God made me'; but when he succeeds, he proudly proclaims himself a 'self-made man.'"

The faculties of the mind are "impression, repression, and expression," which is only claimed to be a sort of a rough classification. The first of these categories includes the senses, through which perceptions of external things reach the mind. Repression is used as a synonym for memory "which by cerebration analyzes all this raw material, combines, recombines, deepens and classifies it ready for expression. . . . Expression uses the material the senses have received and memory has classified,—in writing, speaking, clear formulation in words, drawing, or some other form of outward activity." The impressions received in modern schools are compared to geological strata, lying upon and concealing each other.

"Does not all the inability of an ordinary college graduate lie in matter of expression? Is his mind quick to analyze a new subject and to see it in its new relations? To ask a good question? To give a quick illustration? To make a fair description? To be ready in conversation? To sum up, to epitomize, to formulate his own views? To make a generalization? He has information, but so has a library; he has a vocabulary, but so has a dictionary. To be of service to him in the battle of life his information and his vocabulary must be held in immediate readiness. Mental training recognizes these three divisions; gives each careful exercises to keep each in its best condition as a part of the instrument, and then trains the mind to pass every impression through the trifold process—a training that soon results in automatic action.

"One illustration out of a number showing deficiencies in training the senses, is that 'men fail in spelling, hopelessly surrendering to the belief that they can never learn to spell, because the power of visualizing words has never been developed.' Pronunciation of words is hardly ever entirely correct because the sense of hearing has not been trained to detect nice distinctions between different sounds. Defects in penmanship result from lack of suitable muscular training, and the training of the eye to detect differences in form. That with any one sense weak, our impression of the whole is weakened in proportion" is a most important proposition. An illusion is not a failure of one or two senses only to derive correct impressions of external objects, it involves the deception of all, or at least so many that wrong impressions preponderate, and right impressions are too feeble to correct the erroneous ones.

"Constant training in words is a vital part of mental training. When the powers of expression are strengthened and exercised, they react upon the faculties of impression. The more clearly we can express ideas, the more accurately and readily can we receive them. This one great need in education to-day is passed by with a trivial recognition that is a disgrace to education." The rigidity of systems in modern public schools is denounced. Both teachers and pupils work in one groove constructed by some superintendent, who fancies his ideas are original and superior to all others, and whose methods, nine times out of ten, are reflections of his own defective training. This has the effect of suppressing all originality on the part of the teachers employed, and native genius for teaching is thus cramped. Another mind is interposed between that of the pupil and his instructor, which like an impenetrable screen prevents direct and close contact.

Prof. Dewar's Latest Experiments.

IN the *New Science Review*, an able quarterly recently started in New York, the second number of which is rich with the newest discoveries in science, and with discussions of scientific topics now taking front rank in importance, the first of the leading articles is by Prof. James Dewar who has won a world-wide fame by his brilliant experiments in the liquefaction and solidification of gases through the influence of extremely low temperatures. From time to time the results of these experiments have been noted and their possibilities have been pointed out in these departments. Some results not anticipated have, however, been reached, and it is with unexpected phenomena of fluorescence or phosphorescence, that Prof. Dewar deals in his paper.

It is editorially explained in a foot note that Prof. Dewar's health having been impaired by overwork, only the first portion of the article was written by him; but the material furnished by him for the completion of the paper has enabled an account of his experiments, in lines indicated by the title, to be prepared.

The effects of the extremely low temperature obtainable by the evaporation of liquid oxygen, which, as Prof. Dewar has shown is capable of condensing atmospheric air to a liquid and even congealing it, modify some physical properties which bodies manifest at ordinary temperatures and this in quite unexpected ways. For instance, contrary to general anticipation the property of elasticity is found to be much increased.

"This modification of elasticity—both longitudinal and torsional—was clearly shown by cooling spirals of very soft metal in liquid oxygen to —180° C., when they became perfectly rigid and sonorous, like iron. The influence of similar cooling upon hard steel was demonstrated by comparing the notes from two tuning-forks in perfect unison. On cooling one to —180° C. its elastic constants were modified, thus causing it to vibrate more quickly than the other, while the number of beats showed the increased elasticity."

Direct chemical reaction, and voltaic action appear to cease at a temperature of 180° C. (93° C. above the absolute zero); but photographic effect is continued at —200° C., its energy, however, being diminished 80 per cent.

Color is also affected; for example liquid oxygen turns red, and iodide of mercury turns yellow

But the most remarkable effects, if any can be called more remarkable than others, are those pertaining to phosphorescence or fluorescence. In these experiments another example of the insight afforded by extreme conditions in physical researches, is added to that of Prof. Crooke's experiments with extremely attenuat d gases, and to those of Tesla with rapidly alternating electric currents.

"Gellatin, celluloid, paraffin, ivory, horn and India-rubber become distinctly luminous, with a blueish or greenish phosphorescence, after cooling to —180° C., and upon being stimulated by the electric light. Hydrokinone is more luminous than the isomeric resorcin or pyrocatechin; in the same way pyrogallic acid was shown to be faint as compared with phloroglucin. All alkaloids forming fluorescent solutions become phosphorescent at low temperatures. The hydrocarbons, alchols, acids and ethers of the fatty series are all more or less active, and glycerin, sulphuric, and nitric acids are all very bright, whilst concentrated hydrochloric acid and strong ammonia are also very bright. Colored salts generally show very little activity. Water when pure is only feebly phosphorescent, but remarkably so when impure. Acetic acid and acetanide appeared fairly equal in luminosity; hippuric acid was very fine, and so were most substances containing a ketone group. Lithium platino-cyanide changed from white to red on cooling, and was excelled in phosphorescing power by yellow ammonium platino-cyanide, which was exceedingly bright.

"Definite organic substances possessing exceptional powers of phosphorescence, when stimulated at —180° C., are acetophenone, benzophenone, asparagin, hippuric acid, phthalic anhydride, urea, cretin, urethane, succinimide, triphenyl methane,

diphenyl, salicylic acid, glycogen, aldehyde, ammonia, etc.

"Very remarkable were some results obtained by the professor with an egg and a feather. The egg shone brilliantly as a globe of blue light, its outline in the darkened theater being clearly seen. Other organic substances giving excellent results were cotton, wool, paper, leather, linen, tortoise shell, and sponge, all of which phosphoresced brightly, as did also a white flower, a cultivated species of dianthus. Colored glasses and papers do not, as a rule exhibit any phosphorescence, and when the alchols are colored by the addition of a trace of iodide, the luminous effect is destroyed. Milk was shown to be highly phosphorescent and much brighter than water. Metals also phosphoresce, but in this case the action is due to some organic film deposited from the air, because it disappears on ignition. If the metal is subsequently touched, the phosphorescence reappears."

Ordinary albumen is more phosphorescent than the yolk of egg. In general, however, white bodies are found inferior to colored ones in this respect. "Caustic soda and many salts not normally phosphorescent are markedly so at low temperatures."

The physical significance, if any there be, of these new facts as related to the ultimate nature of matter is, of course, yet to be made the subject of scientific speculation. They are too recent to determine whether any new light will be shed by them upon atomic conditions, which the Marquis of Salisbury in his inaugural address before the Royal Institution included among the yet "unsolved problems of science."

Utilization of Waste Carbonic Acid Gas in Breweries.

IT is said that the quantity of carbonic acid (carbon dioxide) evolved during fermentation is approximately equal in weight to the alcohol produced. Mr. A. Marcot, in the Transactions of the Brewing Institute, describes the method and apparatus employed for collecting and compressing this formerly waste product, and an abstract of his paper is given in the *Scientific American Supplement*. The rapid evolution of the gas begins in breweries about 20 hours, and in distilleries about 6 to 8 hours, after "pitching," and for some time afterward continues at such a rapid and regular rate that it can be drawn off by the compression pumps without admixture of air. If however air is introduced, it can be got rid of by a special release valve. A parachute or skimmer is used to collect the gas, provided with raising and lowering gear that keeps it just above the level of the yeast. The level of the carbonic acid is shown by a collodion balloon which floats upon its surface.

After compression to one atmosphere the gas is purified by passing through water, sulphuric acid and a week solution of potassium permanganate. In the third stage of compression the pressure reaches 60 atmospheres and the gas then passes to condensing coils cooled by water and is liquefied. Obtained in this way, it has a purity of 99.5 per cent. and is odorless. At the plant described the liquefied gas is used as a source of power in place of the ordinary pumping engines. It has also a commercial value for a variety of purposes, from aërating water and bread to hardening armor plates.

Electrolytic Production of Chlorine and Soda.

IN the November issue of this Magazine (p. 317) an article by Mr. H. Y. Castner on the electrolysis of alkaline chlorides, published in the *Engineering and Mining Journal*, was commented upon. M. Emile Andresoli now communicates to the *Electrical Review* some remarks upon the subject which might appropriately be called caustic. With some slight implied disparagement of electrolytic methods thus far employed for the purpose, he remarks that "it is usual for people who write or deliver lectures on the production of chlorine and caustic soda by electrolysis to predict that the Leblanc and Solvay processes are doomed, and that a new system has been found which will revolutionize the alkali industry, and supersede everything which

has been done up to the present." He then refers to an article in the London *Times* upon the new electrolytic process as showing rather too much enthusiasm for an apparatus "which is so superior, so efficient, so cheap, and so perfect, that all the others are nothing in comparison with it."

Electrolytic methods for producing chlorine and caustic soda are grouped into three classes: (1) The decomposition of chloride solution with electrodes not absorbing the products of electrolysis; (2) the mercurial process, in which mercury is used as a cathode to form a sodium amalgam; (3) the dry process, or electrolysis of fused chloride of sodium or potassium. The Castner process belongs to the second category, and its novelty consists in the continuous tilting or rocking of the tanks, to give the mercury a flowing motion from side to side. It is a continuous process, and M. Andresoli says that a non-continuous one would be worthless; but that there are other continuous methods of the same class.

The author admits that the day is perhaps not far off when the electrolytic process will compete with the chemical manufactures as much as, or more than, electric lighting does with gas; but doubts whether present electrolytic methods themselves will not be superseded long before that day. As to the "dry" processes, "the sole question is to know how the electrolysis of fused salt will behave on a commercial scale."

Incidentally, in adverting to the *Times* article, M. Andresoli contends that the technical press ought to be the first to investigate and appreciate new discoveries, and thinks that "it is almost a breach of etiquette for the daily newspapers to trespass on the ground of the technical press and to give the assistance and prestige of an advertisement in a largely circulated paper," etc. Here is revived an old controversy in which there is always room for argument.

IN "Responsibility in Crime from the Medical Standpoint" (*Pop. Sci. Monthly*, Dec.), Dr. Sanger Brown makes the propositions, that the functional product of brain is mind, and that prevention of crime results from inhibitory brain centers established by means he sets forth.

INDEX TO LEADING ARTICLES.

The journals quoted are indicated by initials, and their full titles are given in the opening pages of the Review. Other abbreviations are, Ill=Illustrated; W=Words.

25800. The Lardarelo Boric Acid Works (Sc A S-Oct. 13.) 700 w.

26674. Erection of the Battle Monument, West Point, N. Y. (E R-Nov. 10.) 1400 w.

*26714. Technical Education (E-Nov. 2.) 1400 w.

*26722. Note on a Collection of Carboniferous Trilobites From the Banks of the Hodder, Near Stonyhurst, Lancashire. Ill. Henry Woodward (G M-Nov.) 2800 w.

*26723. Yumuri Valley of Cuba—A Rock Basin. J. W. Spencer (G M-Nov.) 800 w.

*26724. Problems Connected With a Cooling Earth. Arthur Vaughan (G M-Nov.) 1800 w.

*26725. The Volcanic Phenomena of Vesuvius and Its Neighborhood (G M-Nov.) 1400 w.

*26754. Mr. H. Y. Castner Replies to Criticisms Concerning His Electrolytic Process of Producing Soda and Chlorine (Inv-Nov. 3.) 1400 w.

*26755. A New Method of Reducing Metallic Oxides. H. W. Greene and W. H. Wohl (Inv-Nov. 3.) 500 w.

*26757. Youth of Great Inventors (I C B-Nov. 2.) 3000 w.

*26771. Past and Present. T. H. Huxley (N-Nov. 1.) 2400 w.

*26772. On Recent Researches on the Infra-Red Spectrum. S. P. Langley (N-Nov. 1.) 4500 w.

*26774. Cathode Rays (E R L-Nov. 2.) 1500 w.

26790. Management of Men—A Consideration of Executive Functions. B. F. Spalding (A S-Nov. 10.) 2500 w.

26820. The Prevention of Noise (Sc A-Nov. 17.) 700 w.

*26837. Technical Education (A L-Nov. 2.) 1200 w.

26857. How to Build a Town—An Object Lesson From the Pacific Slope. J. C. Ransom (T-Nov. 15.) 1000 w.

26877. A New Disinfectant—Formalin. Louis Stern (An A-Nov. 18.) 600 w.

26866. The New Engineering Building at the University of Illinois. Ill. (E N-Nov. 15.) 900 w.

†26919. Fluorescence or Phosphorescence,

We supply copies of these articles. See introductory.

and Photographic Action at Low Temperatures —Professor Dewar's Latest Experiments (N S R-Oct.) 1600 w.

†26920. Mental Training—A Remedy for "Education." William George Jordan (N S R-Oct.) 6000 w.

†26921. "The New Element of the Atmosphere"—Considered by Professor Dewar (N S R-Oct.) 1000 w.

*26958. The Technology of Explosives. W. J. Orsman (I C T-Nov. 9.) 3500 w.

*26987. The Search for a Unit of Light. O. Lummer and F. Kurlbaum (El-Nov. 9.) 1500 w.

†26995. Hermann von Helmholtz. Arthur W. Rücker (F R-Nov.) 5000 w.

27016. The Scientific Applications of Photography. (Extract.) Henry Trueman Wood (Sc A S-Nov. 24.) 1300 w.

†27053. Responsibility in Crime from the Medical Standpoint. Ill. Sanger Brown (P S M-Dec.) 2700 w.

†27054. The University as a Scientific Workshop. Freidrich Paulsen (P S M-Dec.) 6500 w.

†27055. The Ancient Outlet of Lake Michigan. W. M. Davis (P S M-Dec.) 7400 w.

†27056. The Geology of Natural Scenery. Frederick J. H. Merrill (P S M-Dec.) 2700 w.

*27095. Tariff Changes and Customs Regulations.—Russia, the Netherlands, East Indies, Switzerland, Belgium, France, Spain, Italy, Bulgaria, United States, Hayti, Guatemala, Brazil, Cape Colony (B T J-Nov.) 4400 w.

*27108. Some Important Experiments With a New Explosive (Inv-Nov. 17.) 900 w.

27139. The Awning Over the Colosseum in Ancient Rome. Henry T. Blake (Sc A-Dec. 1.) 1800 w.

27142. On Some Magnetic Characteristics of Iridium. S. H. Brackett (Sc A S-Dec. 1.) 900 w.

27143. The Koniscope. J. G. McPherson (Sc A S-Dec. 1.) 1700 w.

27144. The Horse as a High Speed Engine. R. H. Thurston (Sc A S-Dec. 1.) 3000 w.

†27152. Atmospheric Resistance. Walter L. Webb (P E C P-Nov.) 3300 w.

†27167. Suggestions for an Index of Engineering Literature. George D. Shepardson (T A I E E-Nov.) 2200 w.

*27243. The World's Debt to Astronomy. Simon Newcomb (Ch-Dec.) 3500 w.

*27252. The Use of Explosives for Mechanical Flight (Inv-Nov. 24.) 2000 w.

27266. Analysis of Electrolized Water Pipes. Joseph Rigge (A G L J-Dec. 3.) 1600 w.

27280. Weathering of Fuel. William White, Jr. (R A-Nov. 30.) 1600 w.

*27290. Alexander Siemens' Presidential Address to the Institution of Junior Engineers (El-Nov. 23.) 4800 w.

*27296. The Construction of Engineering Formulæ. Frederick Grover (P Eng-Nov. 23.) 800 w.

†27313. On the Gunning Method for Total Nitrogen in Fertilizers. W. E. Garrigues (J A C S-Dec.) 700 w.

*27331. Recent Improvements in the Chemical Industry (I C T-Nov. 23.) 1600 w.

†27332. Schiaparelli on Mars (N-Nov. 22.) 5300 w.

27353. The Search for the Absolute Zero. Ill. Henry J. W. Dam (P A-Dec. 1.) 3800 w.

†27373. Inversion of Temperatures in the 26 68 Day Solar Magnetic Period. Frank H. Bigelow (A J S-Dec.) 4000 w.

†27374. The Duration of Niagara Falls. J. W. Spencer (A J S-Dec.) 5800 w.

†27376. Distribution and Probable Age of the Fossil Shells in the Drumlins of the Boston Basin. W. O. Crosby and Hetty O. Ballard (A J S-Dec.) 3600 w.

*27380. Why Is Artificial Flight So Difficult of Invention? Ill. Otto Lilienthal (A E R J-Dec.) 2200 w.

†27390. The Determination of Melting-Points and the Composition of Some Candle Material. W. E. Garrigues (J A C S-Dec.) 1400 w.

27400. The Influence of Occupation on Eyesight (Sc A-Dec. 8.) 1100 w.

27403. Use of Photography in Topographical Drawing. Ill. A. Laussedat (Sc A S-Dec. 8.) 2200 w.

27406. Economic Entomological Work in the Aaks of New York City. E. B. Southwick (Sc P S-Dec. 8.) 1400 w.

Serials.

21763. Engineering Practice and Education. Gaetano Lanza (J F I-Began May—9 parts to date—45 cts. each).

24462. Graphic Statics. W. W. F. Pullen (P Eng-Began Aug. 10—8 parts to date—30 cts. each).

25885. Engineering Lectures. Walter M. McFarland (Eng-Began Oct. 13—4 parts to date—15 cts. each).

26050. Some Remarks on Modern Naval Tactics. By "A Captain of a Battle-ship" (E-Began Oct. 12—Ended Nov. 2—4 parts—30 cts. each).

26560. Indiana Industries (Ir Age-Began Nov. 8—2 parts to date—15 cts. each).

26759. Mosaics. B. Bentley Young (I C B-Began Nov. 2—Ended Nov. 9—2 parts—30 cts. each).

26984. Optical Activity as a Guide to Chemical Constitution. William Huntington (C T J-Began Nov. 10—Ended Nov. 24—3 parts—30 cts. each).

26996. Statistically Indeterminate Structures and the Principle of Least Work. Ill. (E-Began Nov. 9—2 parts to date—30 cts. each).

27084. Early British Races. Ill. J. G. Garson (N-Began Nov. 15—2 parts to date—30 cts. each).

27198. Refrigeration and Ice making (S E-Began Nov.—1 part to date—15 cts).

COMMENT & CRITICISM

A Flying Machine That Flies.

ANNOUNCEMENTS reaching us from England indicate hopeful progress in the completion of Mr. Maxim's flying machine. Here, at last, is a machine that "in its proper motion," ascends. Hitherto the trouble with flying machines has mostly been that they had to be held up by some independent outside force. It is quite refreshing to hear now of one that has to be held down during experiment, and it is quite evident that Mr. Maxim has solved the problem of rising in the air, sustaining, and propelling by power supplied from a motor carried by the machine.

But how about the alighting? There seems to remain a set of problems that, in so far as the machine or the results of the trial give any indication, remain yet unsolved.

In the department of "Popular Miscellany" page 418, Vol. 1, of this magazine, I had the pleasure of writing with reference to this machine and its gifted inventor that the problem of the flying machine "has at last been taken up by exactly the right man who has gone about its solution exactly in the right way." This remark was partly based upon personal acquaintance with Mr. Maxim, and some knowledge of his methods in attacking mechanical problems. The same considerations warrant the belief that the difficulties in safely bringing down his machine to terra firma have not been overlooked by him, and to the anticipation that some very original and ingenious contrivances which will secure the desired result, will be the outcome of his studies on these problems.

L. ALLEN.

Brooklyn, 1894.

Power for Cotton Mills.

IN the November number of THE ENGINEERING MAGAZINE is a very interesting account of the Great Dam at Austin, Texas, and in it Mr. J. T. Fanning, C. E., is reported as saying, "450 horse-power will run a cotton-mill with 50,000 spindles on cloths adapted to the local jobbing trade." Now there is a great error here, either in some one's quotation of Mr. Fanning, or Mr. Fanning's quotation from some one else, as stated.

The lowest amount of power used in New England is at Fall River, on cheap print cloths, all "mule spinning," where I have found it as low as 15 horse-power per 1000 spindles. From that it runs up to 30 horse-power per 1000 spindles, on coarse goods, at Lowell and Manchester on "frame-spinning," such as is generally used at the south. This would give in one case 750 horse-power, and in the other 1500 horse-power for 50,000 spindles, and as I understand the general run of southern mills, it would not be safe to estimate on less than 25 horse-power per 1000 spindles, 1250 horse-power for a mill of 50,000 spindles, instead of 450 as quoted.

SAML. WEBBER.

Charlestown, Mass.

Currency Reform.

BY your December number I notice that you advocate the so-called "Baltimore Plan of Currency Reform." This plan should more properly be called "Currency Deform"; the idea of handing over to the banks complete control of the power of association, the power of the people to exchange services, commodities, and ideas among themselves, being simply monstrous and wicked. It is not so much reformation of the currency which is needed as the putting of a curb on the banks, and preventing them from over-trading in times of ease and placing the business of the country on a certain basis, to be followed by contraction and ruin on another basis in times of peril,—a peril generally created by the banks themselves. Every financial crisis is simply a bank crisis

resulting from overtrading, followed by an attempt to undertrade.

After the destruction, the misery, the demoralization and the crime caused by the banks, especially those of New York city, in 1893, it requires a vast amount of assurance, not to say *brass*, on the part of those banks to propose to the American people a reform in the currency, by placing more power of destruction in the hands of those wretches.

The currency is all right, so far as it goes; its one and only defect being that there is not enough of it; the sole trouble existing in a surplus in 1893 of *bank wind*, followed by a famine of *bank-wind*.

Since the commencement of your magazine you have given countenance to the fallacies of Mr. Edward Atkinson, of Boston, whose fallacies have been effectually and finally turned down by the elections of this year. Take a lesson by this experience of the Atkinson philosophy and proceed slowly in advocating even a more vicious and more selfish philosophy of the bank-ring of New York.

HENRY CAREY BAIRD.

Philadelphia, Dec. 5, 1894.

Steam Engine Governors.

REFERRING to article on Steam Engine Governor in your October issue, I would refer you to a paper by F. M. Rites read before the American Society of Mechanical Engineers, and forming part of vol. 14 of the Transactions, in which the author by mathematical methods attempts to show the preponderance of inertia effects over those due to centrifugal force in an especial form of shaft governor. The question as to whether one set of forces is of more importance than another or acts quicker is not thereby demonstrated to the satisfaction of all.

While it is conceivable that a shaft governor may be so designed that the inertia moments may be in the same direction and supplementary to those of the centrifugal forces, it is evident from an inspection of the cut 5 in the article, that there is but one direction of rotation in which this would be true of the form shown, and that the leverage or moment arm of the tangential component of inertia is in that case small as compared with the leverage of the centrifugal force. It is evident that the forces of whatever nature are given a large leverage on the eccentric connection to weights at the same time that the point of connection is so made that a small movement of weights causes a larger movement of eccentric. The eccentric pivot and pivot of weights are supported rigidly from the engine shaft, and that therefore in order to move the eccentric the balls or weights must change position, a fact in direct opposition to the principle of the Siemens governor. While the tangential inertia of the weights acts through small leverages and varies only directly as the velocity, the centrifugal force varying as the square of the velocity and acting through large leverage would have a preponderating influence. I have a firm conviction that too much importance is placed on the effects of inertia in this style of governor and that the results obtained are due more to the arrangement of leverage through which the forces act than any other one cause.

The question of close regulation is one of growing importance and anything relating to the subject coming from men of experience is interesting.

J. C. HOBART.

Cincinnati, Ohio.

NEW BOOKS OF THE MONTH

PUBLICATIONS OF THE LICK OBSERVATORY OF THE University of California, printed by authority of the Regents of the University. Vol. 3, 1894. Sacramento State Office: A. J. Johnson, Supt. State Printing, 1894. [Cloth, 4to, 229 pp., and 16 full size plates.]

THE book comprises four parts: Part I. Selenographical Studies, based on negatives of the Moon taken at the Lick Observatory by Prof. L. Weinek. Part II. Report on Specimens of Crown and Flint glass belonging to the Lick Observatory and manufactured by the Messrs. Feil; by Prof. C. S. Hastings. Part III. Investigation of the Glass Scale "A," of the Lick Observatory Measuring Engine; by Mr. O. H. Tittmann. Part IV. Spectroscopic Observations of Nebulæ, made at Mount Hamilton, Cal., with the 36-inch Telescope of the Lick Observatory; by Prof. J. E. Keeler. A list of works issued by the Lick Observatory and a list of errata complete the text.

In the first part the splendid heliogravure illustrations deserve special mention. These are: (1) Heliogravure from a photograph of the moon, taken two days after the first quarter, in the focus of a 36-in telescope (not enlarged); (2) From a drawing of *Mare Crisium* and vicinity, by Prof. Weinek (4-fold enlarged); (3) From a photographic enlargement of *Mare Crisium*, by Prof. Burnham (2-fold enlarged); (4) From a photographic enlargement of *Langrenus, Vendelinus, Petavius*, etc., by Mr. Colton (7-fold enlarged); (5) From drawings of *Archimedes* (2 views), and of *Arzachel* (2 views), by Prof. Weinek, (10-fold enlarged; (6) From a drawing of *Petavius*, by Prof. Weinek (20-fold enlarged); (7) Lithograph of Maedler's Chart of *Petavius* (reduced to the same scale as the preceding); (8) Heliogravure from a drawing of *Vendelinus*, by Prof. Weinek (20-fold enlarged); (9) From a drawing of *Langrenus*, by Prof. Weinek (20-fold enlarged); (10) From a drawing of *Copernicus*, by Prof. Weinek (20-fold enlarged); (11) Index map to the drawing of *Copernicus;* (12) Heliogravure from a photographic enlargement of the *Lunar Apennines*, by Mr. Colton (7-fold enlarged); (13) Index map to the *Apennines*, by Prof. Weinek; (14) Autotype, from a photographic enlargement of *Tycho*, by Prof. Weinek and Dr. Spitaler (24-fold enlarged); (15) Phototype of the drawing of *Capella* and *Taruntius*, C, by Prof. Weinek (40-fold enlarged), and (16) Lithograph of the *Visible Spectra* of Planetary Nebulæ, from drawings by Prof. Keeler. The book deserves great credit for the style in which it is printed, as well as the interesting character of its contents.

THE EVOLUTION OF MODERN CAPITALISM. A STUDY OF Machine Production. By John A. Hobson, M. A., author of "Problem of Poverty." London: Walter Scott, Ltd., 24 Warwick Lane. Charles Scribner's Sons, New York, 1894. [Cloth, 12mo, xvi.-383 pp. Price, $1.25.]

THIS book is an attempt to express and illustrate some of the laws of the structural changes in modern industry. The author says in his preface that he has chosen a focus of study between the wider philosophic survey of treatises on Social Evolution and the special studies of modern machine industry, contained in such works as Babbage's Economy of Manufactures and Ure's Philosophy of Manufactures, or more recently in Prof. Schulze-Gaevernitz's careful study of the cotton industry. He calls attention to the fact that the sub-title, "A Study of Machine Production" indicates a further narrowing of the investigation. A clearer recognition of organic unity is sought by dwelling upon the more material aspects of industrial change which mark off the last century and a half from all industrial epochs. The position here assigned to machinery as effected in industrial evolution is selected because the author thinks it is essential to choose some single clearly appreciable standpoint in bringing scientific analysis to bear upon phenomena so com-

plex and so imperfectly explored. The book commences with an introduction, in which the following topics are discussed: Industrial Science, its Standpoint and Methods of Advance, as Factor in Modern Industrial Changes; Place of Machinery in Evolution of Capitalism; The Monetary Aspect of Industry; The Literary Presentment of Organic Movement.

In succeeding chapters The Structure of Industry before Machinery; The Order of Development of Machine Industry; The Structure of Modern Industry; The Formation of Monopolies in Capital; Economic Powers of the Trust; Machinery and Industrial Depression; Machinery as Related to Demand for Labor; Machinery and the Quality of Labor; The Economy of High Wages; The Effects of Modern Industry upon the Workers as Consumers; Women in Modern Industry; Machinery and the Modern Town; Civilization and Industrial Development; with many sub-topics are discussed.

ELECTRICITY ONE HUNDRED YEARS AGO AND TO-DAY. By Prof. Edwin J. Houston, Ph. D. New York: The W. J Johnston Company, Ltd. [Cloth, 12mo, 186 pages, $1.]

THE basis of this little work is a lecture delivered some time before the Electrical Section of the Brooklyn Institute which was a running commentary upon the various steps of progress of the science from that time to this day, and suited to the lay mind. The subject was admirably handled both historically and otherwise and many pretty conceits introduced. One of these which particularly pleased those who heard the lecture was the simile drawn between electricity and Aladdin's wonderful lamp.

The present book contains the lecture in full, with copious additions chiefly of a historical character. In fact it may be said that the book is made up with historical data, to which have been added the lecture above referred to. But taking the lecture as a text he has added footnotes giving abstracts from the original papers whence he had received inspiration, and also extracts from contemporaneous writers. The book is, therefore, a very valuable compendium of historical incidents, facts and data, but it has been arranged so badly as to lose much of its value. There are footnotes within footnotes sometimes down to the third or fourth degree, and although an attempt has been made to distinguish the degree of descent of the footnote by difference of type it is often difficult to distinguish the one from the other. The author was apparently fully aware of this fault for he has deemed it necessary to apologize in his preface for the shortcomings of his publisher.

The book however is a very readable one, and were it not for the glaring faults of arrangement referred to could be praised.

THE METAL WORKER ESSAYS ON HOUSE HEATING BY Steam, Hot-Water and Hot-Air, with Introduction and Tabular Comparisons. Second Edition, Revised, New York: David Williams, 1892. [407 pp., 7 × 9½ inches Cloth. Price, postpaid, $3.00.]

THE foundation of this book is the text of prize essays—two on Combination Systems of Heating, four on Steam Heating Systems, three on Hot-Water Circulating Systems, and six on Hot-Air Systems which were written in response to prizes offered by *The Metal Worker* in the fall of 1888, and subsequently printed in *The Metal Worker*. They attracted much attention at the time of their appearance, and were commonly known and spoken of by the name chosen as a title for this book. The work, however, contains much more than these essays. Naturally, heating engineers did not agree with all the views of the writers of the essays, and criticisms upon them were made by a number of experts, emphasizing their strong points, and calling attention to deficiences. Thus supplemented the essays became in reality a practical treatise on the heating of dwellings, and as such was republished. The value and popularity of the book has been much enhanced in this second edition by a chapter on proportioning heating surfaces (written by an able heating engineer) Mr. John J. Hogan, in which no less than twelve series of rules are given, believed to comprise all the methods in use for ascertaining what must always be the first datum for planning a heating apparatus, viz., the amount of heating surface needed to do the required work.

MECHANICAL DRAWING. PROJECTION DRAWING; Isometric and Oblique Drawing; Working Drawings. A Condensed Text-book for Class-Room Use. By Walter K. Palmer, M. E., Department of Drawing, Miller Manual Labor School, Crozet, Virginia, Columbus, O.: Charles B. Palmer. [Cloth, 8vo, 50 p. $0.80.]

WHILE every competent instructor in mechanical drawing has his own ideas as to the peculiar requirements of his pupils, and prefers to exercise his own judgment as to the best methods of instruction in the details of the art, there are nevertheless certain fundamental principles and general rules which must always be presented in much the same way. This work has evidently been prepared with much care by a skillful instructor, to serve as an elementary text-book in the class-room, and as a manual of reference for the future use of the pupil. Its aim is to guide the student to develop for himself the essential principles of the art in a natural and progressive order, and to make his own illustrative drawings as he goes along. The course of instruction laid out appears to be admirably adapted to form in the mind of the student a habit of working from a knowledge of principles, instead of merely copying in a mechanical way, the examples which may be placed before him. The work is very handsomely printed.

THE TELEPHONE HAND BOOK. By HERBERT LAWS WEBB, Member Am. Inst. E. E., Inst., E. E. London. Author of Practical Guide to the Testing of Insulated Wires and Cables. First edition; Chicago: London Publishing Company, 1894. [Cloth, 146 pp., 3x6¼, price $1.]

THIS little book is from the pen of an esteemed contributor to THE ENGINEERING MAGAZINE and he is widely known as a writer on electrical subjects. Mr. Webb states in his preface that this is the first practical book on American telephone methods. As such it will doubtless be acceptable to American readers, especially those interested in telephony. The book is based entirely on standard American practice, and most of the material, apparatus and methods described are peculiar to or have originated in the United States. Nevertheless, a few chapters dealing with certain forms of transmitters and receivers used in Europe are given for the information of those who are unfamiliar with other types of instruments than those used in the United States. Although the pages are small and the book contains only 146 pages, five of which are devoted to the index, the publishers have managed to crowd into it a considerable amount of matter by using small type.

THERMODYNAMICS OF REVERSIBLE CYCLES IN GASES and Saturated Waters. A full synopsis of a ten weeks' undergraduate course of lectures delivered by M. I. Pupin, Ph. D. Arranged and edited by Max Osterberg, of Columbia College. New York: John Wiley & Sons: 1894. [Cloth, 12mo, 114 p., $1.25.]

THIS is a theoretical introduction to the study and design of heat engines. The treatment is necessarily based on the mathematical formulæ which have been established—partly by experience, and partly by inference—that determine the underlying principles on which heat engines of all kinds, whether driven by steam, gas, or other expansive agency, are built. The work does not refer definitely to these applications of force by name, but presents a general grounding in the elements of both the science and the art of developing power from heat. Every added treatise on thermodynamics—upon which all our modern mechanical progress, whether of steam, electricity or otherwise depends—is a distinct gain, when at least up to the mark of the excellent manual.

BROWN'S DIRECTORY OF AMERICAN GAS COMPANIES GAS Statistics. Compiled and Corrected by E. C. Brown, Progressive Age, 280 Broadway, New York, 1894. [8vo, pp. 159-xxxvi. Price $5.00.]

BESIDES being the most comprehensive and accurate directory of gas companies in America yet published, this book contains a vast amount of statistical information. Not only are the names of the different companies given in the usual alphabetical order, but the amount of capital stock and total bonds outstanding; names of officers; purchasing agents; process of manufacture; population of district supplied; average price of gas for 1894; number of public lamps; price of lamps; lighting hours per lamp, per annum; approximate annual output; candle power, and lowest pressure available for gas-stoves, etc., are also given.

A TREATISE ON ELEMENTARY HYDROSTATICS. By JOHN Greaves, M A., Fellow and Lecturer at Christ's College, Cambridge. New York: Macmillan & Co. 1894. [Cloth, 12mo, 204 p., with diagrams. $1.10.]

THIS is a well arranged, closely classified mathematical treatise on hydrostatics, in which however the author relies on mathematics but does not use the calculus, for the most part. It is a text-book rather than a work of reference, and was prepared for the use of Cambridge students. The discussion is applied in detail to the various forms of machines and appliances, and to the principal phenomena of the science. The sections are arranged mainly in the form of definitions and problems, as they would come up in class work.

THE ELEMENTS OF GRAPHIC STATICS. A TEXT-BOOK for Students of Engineering. By L. M. Hoskins, professor of pure and applied mechanics in the Leland Stanford, Junior, University; formerly professor of mechanics in the University of Wiscousin. New York and London: Macmillan & Co. [Cloth, 8vo, viii+191 p. With diagrams. $2.25.]

IN harmony with the modern practice of engineering, which in every direction aims to simplify work and condense results, Mr. Hoskins has compiled this treatise on graphic statics, in which the diagrams illustrating the relations of stresses and spaces have been based on Bow's well-known notation. The author however has widely extended the application of the original notation. He has also endeavored to comply, as to methods of usage in regard to the technical terms of mechanics, with that of the standard authorities—which is gradually crystallizing into something like a system. Graphic statics apply more especially in the designing, or the criticising, of roof and bridge work, and so form a salient part of modern civil engineering. There is an extension, however, which Mr. Hoskins' admirable work suggests, of the application of the system to machine building, and, in fact, to a larger variety of uses.

BOOKS RECEIVED.

Barrett, P. J.=Electricity at the Columbian Exposition. Including an account of the Exhibits in the Electricity Building, the Power Plant in Machinery Hall, the Arc and Incandescent Lighting of the Grounds and Buildings, the Transmission of Power for the Operation of Machinery, the Subway and Conduits, Electric Fountains, Search Lights, Intramural Roads, Electric Launches, Electric Elevators, Lighting of the Ferris Wheel, Corona Lighting of the Manufactures Building, etc. Chicago: R. R. Donnelly & Sons Co., 1894. [Cloth. 8vo. xv-501 pp.]

Annual Report of the State Engineer and Surveyor of the State of New York for the Fiscal Year Ending September 30, 1893, transmitted to the Legislature January 22, 1894. Albany: James P. Lyon, State Printer, 1894. [Cloth. 8vo. 460 pp.]

Reece, Benjamin=The Cattle Guard Problem. Together with the Law of Cattle Guards and Railroad Fences, Containing Statutes and Decisions of the States of the Union. The Q. & C. Company, Chicago, and New York. [Pamphlet. 8vo. 70 pp.]

Statistics of the American and Foreign Iron Trades for 1893. Annual Statistical Report of the American Iron & Steel Association, presented to the Members September 1, 1894. Philadelphia: The American Iron and Steel Association, 1894. [Pamphlet form. 8vo. 78 pp.]

Fox, Walter C., C. E.=Transition Curves. A Field Book for Engineers. Containing Rules and Tables for Laying Out Transition Curves. New York: D. Van Nostrand Co., 1893. (No. 10 Van Nostrand Science Series.) [Cloth. Price $50.]

Interstate Commerce Commission. = Sixth Annual Report on the Statistics of Railways in the United States for the year ending June 30, 1893. Prepared by the Statistician to the Commission. Washington: Government Printing Office. 1894. pp. 620. 9×6 inches, Cloth.

Annual Report of the City Engineer of Toronto for 1893. Toronto: J. Y. Reid, City Printer. 1894. pp. 125. 9½×6 inches. Appendices A, pp. 25, B, pp. 33, C, pp. 23, D, pp. 8.

Snell Albion T.=Electric Motive Power: The Transmission and Distribution of Electric Power by Continuous and Alternate Currents. With a Section on the Applications of Electricity to Mining Work. London: The Electrician Publishing Company, Limited. 1894. pp. 397. 7½ ×5⅛ inches. Cloth. Price 10s 6d.

Department of the Interior, Census Office. Robert P. Porter Superintendent, Carroll D. Wright, Commissioner of Labor in Charge. Compendium of the Eleventh Census: 1890. Part II: Vital and Social Statistics. Wealth, Debt, and Taxation; Mineral Industries; Insurance; Foreign Born Population; Manufactures. Washington. Government Printing Office. 1894. pp. 1064 11½×7½ inches. Cloth.

Winchell, Alexander. LL. D. Late Professor of Geology and Paleontology in the University of Michigan.=Walks and Talks in the Geological Field. Revised and Edited by Frederick Starr, of the University of Chicago. Flood and Vincent. The Chautauqua Century Press. Meadville, Pa. 1894. pp. 353. 7½×5 inches. Cloth.

NEW TRADE CATALOGUES.

These catalogues may be had free of charge on application to the manufacturer.

S. Wilks Manufacturing Co., Chicago, Ill., U. S. A.=Catalogue, 34 pp. [Steam Generators, Hot Water Heaters, Steel Tanks, etc. For supplying hotels, dwellings, greenhouses, laundries, churches, baptisteries, bath houses, carriage houses, etc., with steam and hot water. Profusely illustrated, with price lists, etc.]

Chas. A. Strelinger & Co., Detroit, Mich., U. S. A.=Catalogue, 306 pp. [A long list of a great variety of bench tools for use in screw cutting, tapping, countersinking, etc. Also milling and gear cutting tools, knurling tools, wrenches, screw drivers, tapes, levels and levelling instruments, hydraulic jacks, emery wheels, punches and punching presses, etc., etc., etc., with price lists.]

The Acme Machinery Co., Cleveland, Ohio, U. S. A.=Catalogue, 108 pp. [Beautifully printed and bound in flexible covers with imprint in gold, and rounded corners. Describes and illustrates an extensive list of bolt cutting machines, taps and dies, with price lists.]

The Vulcan Iron Works Co., Toledo, Ohio, U. S. A.=Catalogue, unpaged. [Steam Shovels and Dredges. Sheets eyeletted together with flexible leatheroid covers, gold imprint. Very elegantly designed; rounded corners. Profusely illustrated with cuts of steam shovels, showing their appearance in operation and exemplifying details of construction.]

The National Switch & Signal Co., Easton, Pa., U. S. A.=Reference Catalogue No. 2, 154 pp., Royal octavo. [Tinted illustrations, flexible covers, imprint in silver, 64 full page plates, with numerous engravings illustrative of details. Describing interlocking and signaling apparatus manufactured by this company.]

Consolidated Car Heating Co., Albany, N. Y., U. S. A.=Catalogue, Part XII (1895 Edition), 30 pp. [Describes electric heaters, cable car heating, lighting by the Pope system, compressed oil gas for cable and steam cars, and by electricity for steam cars. Contains numerous illustrations of the applications of these systems to railway cars, and details of the appliances therefor.

The Ingersoll-Sargeant Drill Co, New York, U. S. A.=Advance sheets of Catalogue No. 50, 32 pp. exclusive of cover. [Illustrated with numerous engravings of coal cutting machines in operation, with sectional drawings illustrating all the parts in such machine assembled together, ready for work. Also a full page plate illustrating a shaft sinking plant. Also illustrations, descriptions and price lists of rock drilling machinery. On the last page of cover is an excellent illustration of an apparatus for pumping water by compressed air by the use of the Pohlé air lift pump. Special attention is called to a statement of the cost of blasting and loading coal at working face, keeping track laid and timbers set in rooms, on page 17 of this catalogue.]

The Sargent Co., Chicago, Ill., U. S. A.= Pamphlet, 11 pp. "The Wheel, the Rail and the Shoe." [The purpose of this book is to show by a description and argument, with the use of liberal Illustrations and diagrams, the advantages of the Sargent Brake Shoe. All the features of the design of this shoe and its evident advantages are excellently presented.]

H. W. Johns Manufacturing Co., New York, Chicago, Boston, Philadelphia, U. S. A. London, Eng.=Pamphlet, unpaged. Heat Insulation and Fire Protection in Prominent Buildings. [Describing very briefly the uses of asbestos in fire proofing buildings and containing a large number of excellent illustrations of such applications in numerous and important buildings in most of the large cities in the United States.]

The Minneapolis Radiator and Iron Co., Minneapolis, Minn., U. S. A.=Catalogue, 48 pp. [Describes and illustrates a long line of appliances for steam and hot water heating, with tables of sizes and capacities, illustrations of details of construction, price lists, etc.]

The Butler Manufacturing Co., Chicago, Ill., U. S. A.=Catalogue, 37 pp. [Some electrical specialties manufactured by this company, among which are lamp hoods for any system, incandescent lamps, street fixtures and reflectors, weather protectors, switches, reflector shades, hanger boards, head lights, station lamps, terminals and connectors, screw cases, bolt cases, water coolers, etc.]

Boston Belting Co., Boston and New York, U. S. A.=Catalogue, 116 pp. [Price list of a very extensive line of rubber goods, including vulcanized rubber goods, machine belting, hose for fire department and domestic use, hose racks, rubber packing, rubber mallets, rubber valves, rubber soleing, rubber springs, corrugated rubber matting, perforated mats, rollers, etc., etc. Also a concise history of the company, and facts relating to vulcanized rubber machine belting, with suggestions for the transmission of power by rubber belting, constituting a complete essay upon the subject, which will be of value generally to mechanical engineers. Elegant cover printed in gilt and tints.]

Electrical and Mechanical Engineering & Trading Co., New York, U. S. A.=Pamphlet, 15 pp. [Describes the Booster System and gives other important electric railway information. The description is illustrated with engravings and the subject is also treated mathematically, with plate diagrams, showing initial cost of steam and generating plant, copper and special apparatus for delivering 200 amperes at 500 volts; operating expenses of plant delivering 200 amperes at 500 volts; comparison between common and Booster feed for railways, showing the investment saved in weight of copper by means of the Booster System, and a table of electrical conductors which comprises much general information for electric railways in compact and convenient form.]

Interior Telephone Co., New York, U. S. A. =Pamphlet, 40 pp. [Illustrating and describing the Colvin Interior Telephone System for inter communication between several departments, in any building, such as hotels, office buildings, stores, factories, steamships, resi-

dences, etc. With numerous testimonials and a list of parties using the System.]

Interior Conduit and Insulation Co., New York, U. S. A.=Circular and price list No. 20, 16 pp. [Describes and illustrates the iron armored insulating conduits and single tube systems of this Co., with all their details. Also a list of pipe cutters, pipe vices, hack saws, stocks and dies for threading pipes, pipe wrenches, etc.]

Fraser & Chalmers, Chicago, Ill., U. S. A. London, Eng.=Catalogue No. 24, Riedler Pumping Engines, 12 pp. [Illustrates and describes these noted mining and water works pumps, and gives an extensive list of places where they are in use. (2)=Catalogue No. 46, Riedler Air Compressors, 12 pp. Manufactured for the United States, Mexico, England, Africa and Australia. A full description of the same and illustrations of the vertical type, a list of catalogues of Fraser & Chalmers, English Editions, in order of numbers, and a discussion of the advantages obtained by the use of these compressors. Also unpaged leaflets describing and illustrating special installments.]

Star Brass Manufacturing Co., Boston, Mass., U. S. A.=Catalogue and Steam Users Manual, 190 pp. [Stiff cover, describes and illustrates an extensive line of pressure and vacuum gauges, marine pop safety valves, and general steam engine and boiler appliances, Also contains a variety of useful information relating to practical steam engineering.]

The Sperry Electric Railway Co., Cleveland, Ohio, U. S. A.=Catalogue, 38 pp. [Describes apparatus for electric railway use, manufactured by this Company. A gem of typographic art. Both the text and the cuts are printed in colors, and the cover is light blue with gold imprint united in a very artistic design.]

The Boston Belting Co., Boston and New York, U. S. A =Catalogue, 29 pp. exclusive of cover. [Describes and illustrates a most extensive line of hose for all purposes to which hose can be applied. Also hose pipe, with notes of information; comprising tables of use in calculation of water pressures at engine through various lengths of hose, with different sized nozzles, pressure in pounds per square inch; velocity in feet per minute, and approximate height in feet to which a jet will be projected when water is discharged from various heights, capacity of cisterns and tanks, etc.]

Trevert, Edward.=How to Build Dynamo-Electric Machinery, Embracing Theory, Designing and the Construction of Dynamos and Motors. Illustrated. Lynn, Mass.: Bubier Publishing Co. [Cloth, 8vo. 3-339 p. $2.50.]

Unwin, W. Cawthorne.=On the Development and Transmission of Power from Central Stations: the Howard lectures delivered at the Society of Arts in 1893. New York: Longmans, Green & Co. [Cloth. 8vo. 5-312 p. $5 30.]

Ed Wertheim, Chicago, Ill., U. S. A.=German Asbestos Goods. 75 p. [Describes sources from which asbestos is obtained, its manufacture, uses, and methods of applying it to various purposes, including boiler coverings, belting, building paper, ropes and rope ladders for fire escapes, insulating tubes, etc.]

Siemens and Halske Electric Co., of America, Chicago, Ill., U. S. A.=1—Bipolar Generators and Motors, Type "L. H." 8 p. 2—Generators and Motors, Type "I." [Illustrated descriptions of both these types of machines and a statement of the advantages of each. Also large page engravings of notable machines erected and in use.]

Niagara Cycle Fittings Co., Buffalo, New York, U. S. A.=Catalogue. 16 p. [10 of which are occupied with accurate tables of diameters, areas, weights, etc., of Cold Drawn Seamless Steel Tubing. Calculated and published by O. J. Edwards, Ellwood City, Pa., 1894, copyrighted; all rights reserved in America and England.]

The Globe Company, Cincinnati, Ohio, U. S. A.=Catalogue of office appliances. 108 p., green and silver gilt cover. [Illustrates and describes a long line of office furniture, including filing cabinets, desks, and other office appliances, with price, and directions for ordering from special designs.]

Weber Gas and Gasoline Engine Co., Kansas City, Mo., U. S. A.=Catalogue, 39 pp. [Describes and illustrates the Weber Gas and Gasoline Engines, of various sizes and types, and adapted to various uses. Gives cost of operating, list of sizes, capacities, and other details, uses to which these engines are adapted; also a long list of testimonials from parties using them, with numerous illustrations, a notable one being that of an adaptation of the engine to the manufacture of ice, and the refrigeration used in a packing house in Kansas City; also another illustrating the application of this kind of power to electric lighting]

The Tanite Co., Stroudsburg, Pa., U. S. A. =Catalogue. 47 pp. [Contains an earnest plea for the better appreciation of the grinding industry. Presents an able argument favoring the substitution of griading for the use of the file and cold chisel in all places where the solid emery wheel can be applied. Also presents practical hints about emery wheels by which their use and efficiency may be largely enhanced.]

The Addyston Pipe and Steel Co., Cincinnati, Ohio, U. S. A.=Pamphlet, 8 pp. "Altitude and Discharge of Fire Streams." [Diagrams, descriptive text and formulæ for the solution of all problems relating to Altitude and Discharge from Fire Nozzles. Both "Smooth" and "Ring" nozzles are treated. By Mr. John Hill, C. E. A little study of the diagrams in connection with the explanatory text will enable the reader to use them with facility, and to rapidly solve all questions comprised within the limits to which they have been constructed. A revised list of standard special fittings, and a table of weights of cast-iron pipe from 2 to 60 inches in diameter are appended.]